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The President's Page

The growing importance of the geophysical sciences, and the outstanding success of the International Geophysical Year, have increased the need for suitable means of quick publication of scientific papers in geophysics. It has become increasingly obvious that our bi-monthly *Transactions* could no longer meet these demands as a prime publication outlet for our science. Accordingly, almost two years ago, wheels were set in motion to provide a medium that would reach the widest appropriate audience, and thus improve the opportunity of geophysicists for prompt publication of their work.

During the same period it developed that Merle A. Tuve, Editor of the *Journal of Geophysical Research*, indicated that he felt that the joining of the *Journal of Geophysical Research* and the scientific content of the *Transactions* would better serve the scientific community.

After extensive studies a special report was adopted at the Executive Committee Meeting in May 1958 [see *Trans.*, Aug. 1958, pp. 762-764]. In effectuating this new plan, it has been the objective of the Executive Committee to emphasize the common interests of all elements of geophysical science. Even at that time the full scope and effect of the changes could not be fully appraised because the means for accomplishing the desired changes under support from the NSF were only in prospect. However, plans proceeded and in early July representatives of the American Geophysical Union and the *Journal of Geophysical Research* met with the Director and staff of the National Science Foundation to ascertain whether plans for an expanded Journal would be supported. A formal application for funds was subsequently laid before the National Science Foundation and was given consideration by the Foundation even while the membership was balloting on the changes in the Statutes which the revised policy involved. The National Academy of Sciences approved the proposed changes, and the membership did likewise by an

overwhelming vote [see *Trans.*, Dec. 1958, p. 1196]. Thus, by mid-September a firm mandate was in hand, and funds were in sight for effecting the contemplated changes.

P. H. Abelson, Director of the Geophysical Laboratory of the Carnegie Institution of Washington, and James A. Peoples, Jr., taking up duties as Professor of Geophysics at the University of Kansas, generously agreed to serve jointly as editors of the new monthly *Journal of Geophysical Research*, and work towards production got underway. Arrangements were worked out with the William Byrd Press in Richmond with respect to printing not only the *Journal* but also the new quarterly *Transactions*. The new *Journal* will contain scientific papers only, along with letters to the editor on scientific subjects and will provide rapid means for publication of contributions in the broad field of geophysics. It is anticipated that the size of this *Journal* will grow rapidly and that in a year or two each issue will contain 200-250 pages.

The joining of the *Transactions* and the *Journal of Geophysical Research* will make for a better balanced journal than either one alone in covering all of geophysics. Active efforts are underway to ensure a good representation of splendid papers from fields not now well represented and from new fields that are an outgrowth of the work of the International Geophysical Year, such as those relating to aeronomy and the Earth's environment within the solar system. Sound scientific papers are welcomed from all parts of the world.

This major improvement in our publication policy involving a greatly expanded journal could not be achieved without cost. The support of the National Science Foundation was, of course, contingent upon strenuous efforts to help ourselves. In deference to the growing recognition of the fact that a research project is not complete until the results are published and the fact that the research budget should thus in-

clude an item for publication, the policy has been adopted of assessing a \$15 page charge, never against the author, but against the author's organization. While this page charge is still not mandatory and, in fact, is not expected from contributions from some organizations overseas, continuing efforts will be made to collect this from all organizations of North American contributors. The acceptance of this page charge carries with it the availability without further charge of 100 reprints of the paper.

The quarterly *Transactions*, for the moment, will receive the other materials previously published in the *Transactions* that were not strictly scientific papers. It will thus include such material as the *IGY Bulletins*, notes and personalia, and information concerning AGU affairs and activities. It is the plan and the hope that this will be a growing organ for the dissemination of geophysical information useful to geophysicists and the intelligent lay public alike. It will be the medium carrying full information concerning IUGG, SCOR, SCAR, COSPAR, and other international activities that provide expanded opportunity for geophysical research. Likewise, in this issue, we have a story of J. Tuzo Wilson's visits to scientific laboratories in the USSR and China. Materials of generally similar character will be carried as occasion permits, and we are thus expecting to develop the *Transactions* as a very useful publication in extending our participation in national and international geophysical affairs.

In discussing the publication policy of AGU in general, we must not overlook the Monograph Series. Nos. 1 and 2 were published, respectively, in 1956 and 1958, and plans are well along for the publication of three more in 1959. We are hopeful that this may be the beginning of an authoritative series covering specialized topics

in geophysics. An AGU Monograph Board is now being formed to plan and screen the series. The objective is to provide a shelf of specialized volumes by individuals, and reporting specialized symposia, that contain major elements of the foundations of geophysics.

The monograph series provides a real opportunity for authors to consolidate whole special fields in authoritative texts, with adequate illustration and notation.

Likewise, the American Geophysical Union is undertaking the translation and publication of *Izvestiya*, Geophysics Series, itself for the year 1958 by means of a grant from the National Science Foundation. The 1957 issues were undertaken on our behalf by Pergamon Press, and the 12 numbers are now available. Commencing with 1958 we expect numbers to be published rapidly so that by late summer or early fall all 12 numbers will be available. Plans are well underway for continuing the project through the 1959 volume. Subscriptions (\$25) should be sent to the AGU.

The interest and support of all of our members—in fact, geophysical scientists in general throughout the world—are enlisted for all of these endeavors, and constructive suggestions and criticisms are invited. In outlining the publication policies there are many other facets of AGU activity through its committees and meetings that have not been touched upon. The *Transactions* should provide a forum wherein national and international problems can be discussed and debated. The whole world is the laboratory of the geophysicist so that international collaboration means more to us than idle speculation. Therefore, contributions looking to advancement of geophysics will be welcomed by the *Transactions*.

MAURICE EWING, President

Geophysical Institutes of the U.S.S.R. and of the People's Republic of China

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INTRODUCTION

Last summer I attended the fifth meeting of the *Comité Spéciale de l'Année Géophysique Internationale* (CSAGI) in Moscow as one of the Canadian delegates. En route to the meetings I traveled through New York, Brussels, Helsinki, and Leningrad. From Moscow I flew to the Caucasus Mountains and to the oil fields in Tataria between the Volga River and the Urals. I returned to Canada through Peking, Sian, Lanchow, Canton, Hong Kong, Taipei, Maioli, and Tokyo. I found that the governments of all the countries which I visited were generous in giving me opportunities to see the geophysical work being done under their jurisdiction. I was invited to go to some places such as Tataria and Peking, but it was I who proposed other visits such as those to Sian, Lanchow, and the Caucasus.

This article is written to give a brief account only of the work which I saw in the U.S.S.R. and in the People's Republic of China, although I received similar generous treatment in other countries.

In case there are any readers not familiar with present-day conditions, I might say that travel into the U.S.S.R. and across Asia was arranged by Intourist and that other trips were planned by the organizations I visited. I flew to and from Eurasia and on side trips in the U.S.S.R., but I deliberately requested train travel from Leningrad to Hong Kong, via Moscow and Peking, a journey which requires a total of eleven days and nights. There were sleeping and dining cars on the trains. I stayed in modern hotels—all

those in China had been built within the past ten years. The food, although at times unfamiliar, agreed with me, and I enjoyed eating native dishes whenever possible. The trip was about as convenient and comfortable as the lecture tour I had made the previous winter to 22 United States institutions in the North Central Plains. Because of another reason (an airline strike), I had made much of that journey by train and bus also.

At all institutions some of the scientists spoke English, and many of the senior Chinese were graduates of American or European universities, but interpreters were also usually present and did their work so well that one scarcely noticed their presence.

There was no interpreter on the train between Moscow and Peking, but I learned a few words of Russian which with a phrase book served requirements.

Except for a few places and subjects, I took photographs freely. Everyone on the whole journey was polite and apparently interested to see me and exchange views.

I was particularly glad to renew acquaintance with many geophysicists, including several of the 43 Soviet scientists, who had attended the Eleventh General Assembly of the I.U.G.G. held in Toronto in September, 1957. Their kindness much more than repaid anything we had been able to do.

I generally managed to avoid political discussions, but it is apparent that our ignorance of many affairs in Eurasia is only matched by their misunderstanding of North America. We are serious offenders in that most of us cannot read Russian or Chinese; most Russians can at least read English; the Chinese frequently can read all three languages.

I should like to express my gratitude to the officials of the academies, institutes, and depart-

¹ Professor Wilson is also President of the International Union of Geodesy and Geophysics. A more popular report of his extensive trip through China will be found in the *Saturday Review*, November 8, 1958, pp. 45-54, where a brief biography of Professor Wilson is also found.

ments, to the scientists, and to the interpreters who made the necessary arrangements and who gave so willingly of their time. The names of many of them are mentioned in the text. This article is based upon notes openly made at the various meetings and in the various laboratories, but I have had little opportunity to check or correct them, and I therefore wish to apologize for any inaccuracies which result from my poor reporting. I hope, nevertheless, that it will give some little idea of the way in which geophysical work is conducted in these countries. My interests are chiefly connected with the solid Earth, so that I did not see any institutes dealing with

the atmosphere or magnetism. The brief account of oceanographical institutes was obtained from G. E. R. Deacon.

There are, of course, very many more institutes than those I saw or even heard of. It will be appreciated that space prevents my mentioning many interesting subjects which I saw and that the coverage given to different institutions reflects the circumstances under which I saw them, as much as their relative interest.

I felt a very real desire on the part of the geophysicists I visited to show me as much as they could of their work. I am sure that more such reciprocal visits could only be beneficial.

Part 1—U.S.S.R.

INSTITUTES OF THE ACADEMY OF SCIENCES OF THE U.S.S.R.

During my stay in the U.S.S.R. I heard of the following institutes and other bodies dealing with geophysics and related subjects which I believe are under the direction of the Academy of Sciences. The names of many others are given in *The World of Learning* (8th ed.), London, 1957. Those which I visited are described in more detail below:

Attached to the Department of Physics and Mathematics of the Academy:

(1) Otto Schmidt Institute of Physics of the Earth, Moscow, Director: Dr. E. V. Karus

(2) Moscow Seismological Station (part of (1)), Director: Mrs. N. V. Kondorskaya

(3) Institute of Physics of the Atmosphere, Moscow, Director: Corresponding Member A. M. Obukhov

(4) Institute of Applied Geophysics, Moscow, Director: Y. K. Fedorov

(5) Special Institute on Earth Magnetism, near Moscow, Director: Professor Pushkov (operates geomagnetic observatories)

(6) Marine Hydrophysical Institute, Moscow, Director: Professor A. A. Ivanov

Attached to the Department of Chemistry of the Academy:

(7) V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, Director: Acad. A. P. Vinogradov

Attached to the Department of Geology and Geophysics:

(8) Institute of Geology, Moscow, Director:

Dr. N. S. Shatsky (includes some geophysical work)

(9) Institute of Precambrian, Leningrad, Director: Dr. A. A. Pulkanov

(10) Institute of Oceanology, Moscow, Director: Prof. V. G. Kort (operates ships *Lomonosov* and *Vitiaz*)

(11) Special Laboratory for Volcanology, Moscow, Director: V. I. Vlodavets (has two field stations in Kamchatka and is closely associated with (7))

(12) V. A. Obruchev Institute for the Study of Frozen Soil, Director: P. F. Shvetsov

(13) F. R. Savarensky Hydrogeological Research Laboratory, Director: Dr. V. A. Priklonsky

In addition to the Academy of Sciences of the U.S.S.R., there are academies for the individual republics. In Tbilisi (Tiflis), Georgia, I visited the Institute of Geophysics of the Academy of Sciences of Georgia.

Otto Schmidt Institute of Earth Science, Moscow—Staff: Director, Dr. E. V. Karus; Deputy Director, Dr. Borisevotch.

In 1935 the Institute of Seismology was founded and in 1938 the Institute of Geophysics. These two were combined in 1947 to form a Geophysical Institute, which was again divided in 1956, this institute becoming one of the parts.

The Institute studies the development of the Earth as a whole, giving principal attention to the interior part and to those features necessary for predicting earthquakes and for prospecting. As a result, the three main problems at which work was then being done were: (a) Origin,

development and internal structure of the Earth; (b) the study of earthquakes and the seismicity of various regions; and (c) the development of geophysical prospecting.

The Institute is also very much occupied with work for the IGY. The Institute has the following scientific departments:

- (1) Evolution of the Earth, Professor B. Y. Levin
- (2) Geodynamics, Corresponding Member V. V. Belousov
- (3) Theoretical Department, Prof. B. I. Davydov
- (4) Internal Structure of the Earth, Prof. Pariiski
- (5) Aerogravimetric Laboratory, Prof. Y. D. Boulanger
- (6) Physics of Earthquakes, Corresponding Member Y. V. Riznichenko
- (7) Seismic Zoning, Professor V. I. Keilis-Borok
- (8) Recording Instruments (or Calibration of Instruments?), Dr. Borisevotch
- (9) Seismology Services, Prof. E. F. Savarensky
- (10) Electrometry, Prof. Zabrievsky
- (11) Seismic Methods for Prospecting, Prof. Gubin
- (12) Magnetometry, Prof. A. G. Kalashnikov
- (13) High-pressure Laboratory, Prof. M. P. Volarovitch
- (14) Mathematical Geophysics, Prof. N. V. Zvolinski

In each of these departments there are several other highly qualified scientists, many of whom are women and whose work may also be well known, as for example, Drs. E. A. Liubimova and V. A. Troitskaya. Some scientists also held other appointments, as is the case with Professors V. V. Belousov and V. A. Magnitsky, both of whom are also Professors of Geophysics in Moscow University.

The Institute trains graduate students and gives higher degrees without reference to any university. I went through a number of laboratories and met many of the above and other scientists. Their work is extremely well known abroad, both for its excellence and because of the active part that many of these scientists have played in the program of the IGY.

The laboratories which I particularly visited

were (1), (2), (3), (6), and (13) in the above list.

With Prof. Levin, I discussed his views on the origin of the Earth, which do not differ greatly from those of G. P. Kuiper of the United States. He has since sent me a new and revised edition of his small book on this subject in English. The subject formed one symposium at the International Astronomical Union meetings last August.

Professor Belousov and his colleagues showed me their charts of the shifting areas of seismicity, a subject much studied in the U.S.S.R. and China, for obvious practical purposes as well as theoretical interest.

They also have built a series of excellent and elaborate scale models for investigating especially the viscosity of the Earth. One set of models uses clays and jellies to investigate geological processes on a time scale of one minute equals one million years. Another set investigates earthquake phenomena with a true time scale in gelatin gels. The models are used only to supplement field observations.

The Department of Physics of Earthquakes particularly described the development of methods of deep seismic sounding by Prof. Hambutsev, a former director of the Institute. About 1947 he began measuring depths of several layers above and below the Mohorovicic discontinuity—a method now used by the Tuimasi expedition of the Ministry of Geology under which it is described. Many of the continental results, which have doubtless been published, were described. For the past two years work has been concentrated in the Sea of Okhotsk and across the Kuril Islands.

The Theoretical Department was concentrating especially on questions of the thermal history of the Earth, the effect of high pressures on thermal conductivity and on phase variations and upon the development of mathematical methods for treating turbulence in the Earth's interior, so that theories of the origin of the Earth's magnetic field can be better investigated.

The Moscow Seismology Station is housed for convenience in the basement of the Academy's Institute of Crystallography. The director is Mrs. N. V. Kondorskaya. I was shown three underground vaults which are set in hard clay (there being no convenient outcrop of bed-rock) and maintained at constant temperature. In

them I saw 11 Galitzin, Kirnos, and Kharin seismographs.

This is the central station of the Russian seismological network of which I was shown a map with 96 permanent stations and 11 temporary stations. Similar maps are on display in other observatories. Six people are employed here to summarize all the earthquake data for the U.S.S.R. and to prepare preliminary bulletins every ten days, based on the results from 20 key stations.

In the laboratory I met Dr. C. Y. Fu, a graduate of McGill University, and a graduate of California Institute of Technology, who is a seismologist in the People's Republic of China. As I later confirmed in China, the Chinese network is closely integrated with that of the U.S.S.R. and uses Chinese copies of the same instruments.

Several research projects are in hand, including studies of the distribution of earthquakes in depth and position, the relation of earthquakes to fault lines in the Pamir region, the relation of earthquakes to structures in the Kuril Islands and the strain-rebound characteristics of different regions.

Marine Hydrophysical Institute, Moscow—Staff (from G. E. R. Deacon): Prof. A. A. Ivanov (sea waves), Prof. A. G. Kolesnikov (pulsations of temperature and of marine currents), Candidate of Science G. P. Ponomarenko (physical oceanology), Candidate of Science P. N. Uspensky (theory of marine currents), Candidate of Science S. P. Levchenko (dynamical oceanology), Candidate of Science V. K. Zhavoronkina (marine chemistry), and Scientist T. K. Zhavoronkina.

V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow—Staff: Director, Academician A. P. Vinogradov; Isotope Laboratories, A. P. Vinogradov; Geochemistry of Rare Elements, V. V. Scherbika; Mineralogy, V. I. Gesimovsky; Geochemistry of Sedimentary Rocks, A. B. Ronov; Crystal Chemistry, E. S. Makarov; Radiochemistry, N. I. Baranov; Magmatogenic Laboratory, N. I. Khitarov; Optics, Spectroscopy, and X-ray Laboratory, E. E. Vainstein. There are five analytical laboratories, each using different methods.

The Institute is divided into two departments of geochemical and analytical chemistry and has 13 laboratories, of which I visited only two—the

laboratories for geochemistry of isotopes and for the behavior of rocks under high temperatures and pressures. (The latter is probably the same as the magmatogenic laboratory above.) The Institute is in a fine, large, new building near the University of Moscow, built in 1952. I believe that there are over 400 workers, half of whom are graduates and 15 of them doctors. No degrees awarded.

I saw several pieces of equipment, some of it used for geochemical studies in the range up to 3000 atmospheres and 600°C. Acad. Vinogradov was particularly interested in the question of the origin of the crust which he considered might have come from partial melting of stony meteorites or eclogites, leaving dunite as a residue.

Several mass spectrometers were in use for studying oxygen, sulphur, argon, and other inert gases from meteorites and rubidium and strontium.

Most of the time in this Laboratory was spent in discussion. Some of Academician Vinogradov's views as I understood them follow.

The ratio of sulphur isotopes 32 to 34 for meteorites is 22.20, for basalt 22.178, and for granite 21.780 indicating a dispersion towards the surface of the Earth.

The silicate phase of stony meteorites contains more elements than do dunites.

The melting of rocks in the Earth follows two different patterns, (1) dry melting without added water or mineralizers and (2) wet melting. Achondritic meteoritic material can be formed by zonal and dry melting of chondritic meteoritic material. This process involves the incongruent melting of some metasilicates (pyroxenes) to form orthosilicates (dunite) and excess silica. The silica-rich melt works its way towards the surface, dissolving other scarce elements and carrying them upwards to form the crust. The amount of silica so formed is limited, not more than seven per cent. Under the most favorable conditions the formation of 35 km of crust would require extraction from 500 km of mantle. Coefficients of extraction and depths of extraction can be calculated for other elements.

This melt or lava which works up from great depths as a result of dry melting is basalt. Dunite is the residue left in the mantle.

The more acid rocks are due to the addition of water. To investigate this, a high-pressure apparatus had been built to extend the solubility

curves for silica in water. This laboratory had used higher pressures in the temperature range of 400° to 500°C than had the Carnegie Institution of Washington, but they recognized that the solubility increased faster with rise of temperature than with rise of pressure. In another apparatus, water was pumped through an olivine basalt melt held at 300 atm and 600°C. The first effluent contained mineral components with up to 92 pct silica, but after some time the composition changed to that of quartz keratophyre. This supported the view that acid rocks were a result of the addition of water.

They had also investigated the stability of Pb Cl₂ in liquid and gas phases and found it far more soluble in the liquid phase.

He was aware of suggestions from United States that a high-pressure form of silica, coisite, might be formed at lower pressures than diamonds and he had therefore looked for evidence of coisite in eclogites and in rocks from diamond pipes, but without success.

I believe that much of this has been published in the Russian journal, *Geochemistry*.

Institute of Precambrian, Leningrad—Director, Dr. A. A. Pulkanov. The Institute was closed for holidays, but I met the director in a rest home for scientists, which was formerly the country estate of Prince Troubetskoi near Moscow. The Institute had recently been visited by George Wetherell of the United States. I was told that there are 78 workers, including 11 doctors. It does not give degrees and was founded in 1951 to deal with Precambrian geology, stratigraphy, structures, petrology, ore deposits, and ages. Most work is done on the Baltic shield, but some also on three other shields, and on three mountain belts. There are new maps of Kola and Karelia area on 1 : 1,000,000 scale—most of European Russia has now been mapped on this scale.

Age determinations are under the direction of Dr. E. K. Gerling, who was a student of Khlopin (at one time a director of the Radium Institute in Leningrad.) They founded the potassium-argon method in 1947 and now have ten workers making potassium-argon age determinations. Work on the rubidium-strontium method was started early in 1958. A second mass spectrometer was received in the summer of 1958. Work on lead methods will be begun when a photomultiplier is received towards the end of 1959.

It was stated that some 800 age determinations had been made by the potassium-argon method, mostly on the Baltic Shield.

In the Baltic Shield they had found about eight periods of intrusives, each 100 to 300 million years long in the period from 3500 million years to the present. In the Ukrainian Shield all rocks were from 1600 to 2500 million years. They were pillow lavas in the Krivoi Rog formation. In the belts of the Urals, Carpathians, and Caucasus, the ages of the crystalline rocks were said to be Paleozoic or at most Proterozoic.

Institute of Oceanology, Moscow—Staff (from G. E. R. Deacon): Director V. G. Kort; Prof. B. G. Bogorov (planktonology); Prof. A. D. Dobrovolsky (physical oceanology); Prof. P. L. Bezrukov (marine geology); Prof. V. S. Bruyerich (marine chemistry); Candidate of Science G. M. Beliyev (biology of the ocean floor); Candidate of Science A. P. Lisizin (marine geology); Candidate of Science K. N. Fedorov (theory of marine currents); Scientist B. N. Philuskin (physical oceanology); and Scientist V. I. Kuksa (physical oceanology).

Special Laboratory for Volcanology, Moscow—Director, V. I. Vlodavets. I did not visit this laboratory but met Dr. Vlodavets. He told me that they have two field stations, both, I think, in Kamchatka. A volcanological station started in 1935 at Kliuchi is headquarters for the study of the 67 active volcanoes in Kamchatka and the Kuril Islands. A geothermal station, founded in 1956 in the Powzhatka River hot-spring region, is a center for experimental borings.

In Moscow are microscopic and chemical laboratories. The laboratory employs about 25 scientists and 20 technicians.

INSTITUTES OF DEPARTMENT OF SCIENCE OF MINISTRY OF GEOLOGY

I visited or heard of the following institutes which I believe were under the direction of the Department of Science (Secretary, Dr. V. V. Fedynsky,) Ministry of Geology:

(1) All-Union Geological Institute, Leningrad, Director: Dr. N. I. Marochkin

(2) All-Union Geological Oil Prospecting Research Institute (for the U.S.S.R. in Asia), Leningrad, Director: S. M. Simakov

(3) All-Union Geological Oil Prospecting Research Institute (for the U.S.S.R. in Europe), Moscow

(4) All-Union Scientific Institute of Geophysical Prospecting Methods, Moscow (chiefly oil and gas), Director: Candidate M. K. Polshkov

(5) Tuimasi Expedition (I visited this expedition which is only one of many; it is part of (4)), Chief: Candidate U. N. Godin

(6) Special Institute for Geophysical Prospecting, Novosibirsk, created in 1957, branch of (4)

(7) All-Union Institute of Methods and Instruments for Prospecting, Leningrad (chiefly mining), Director: G. K. Volusjuk

All Union Geology Institute, Leningrad—Staff: Dr. N. I. Marochkin, Director; Corresponding Member Tatarinov, Associate Director; Dr. T. N. Spizharsky, Chief, Geological Department; Prof. (Mrs.) T. N. Simonenko, Chief, Geophysics Department; others mentioned in text.

History—The Geological Survey of Russia, which existed for many years before 1917, was the parent of this Institute which is still housed in the same building. It in turn has originated the other regional geological surveys of the U.S.S.R. with which it maintains close association. I was informed that prior to 1917 there were only 100 trained geologists in Russia, but that today there are approximately 10,000 men and women with some form of higher education beyond high school, engaged in geological work in the U.S.S.R., and the number of such persons engaged in all forms of solid Earth science (including geophysics, soil surveys, and hydrogeology) is 22,000.

Structure of the Institute—The Institute is under the supervision of the Division of Science of the Ministry of Geology of the U.S.S.R. with headquarters in Moscow. Working closely with the director is an internal scientific council (of which he is a member) which plans the work of the Institute, probes all the scientific work carried on, and receives reports from the various scientists who discuss their results before the scientific council.

There were said to be three branches to the Institute: (1) pure geology and geological surveys carrying out mapping in all parts of the U.S.S.R.; (2) study of the relationships of ore deposits; and (3) study of mineral deposits. The structure of the Institute is stated to be as follows:

(1) *Regional divisions*—These include the Far

East, east Siberia, west Siberia, the Urals, Europe with the Caucasus, and mid-Asia with Kazakhstan. These divisions besides making geological surveys, work with and endeavor to improve the work carried out by local geological surveys.

(2) *Institute departments*—These include departments dealing with petrology, lithology, minerals, nonmetallic deposits, metallogenic provinces, and geophysics.

(3) *Technical laboratories*—These include chemical, absolute age, thermal, x-ray laboratories, and so forth.

Training—An important department of the work of this Institute lies in training, for this Institute like many others gives degrees to aspirant candidates and doctors (that is, graduate students) without reference to any university. It is for this reason that some members of the staffs of government institutes are called professors. Some graduate students receive scholarships to work in Leningrad; others work elsewhere and many even receive degrees in absentia if they pass the necessary exams.

About 1700 people work in the Institute in Leningrad alone, of whom 55 are doctors, 220 are candidates, and 800 altogether have college degrees. The Institute has other staff in all parts of the U.S.S.R. The degrees (Diploma, Candidate, and Doctor) are the closest equivalents to our degrees of Bachelor, Master, and Ph.D., but I believe that the candidate and doctorate degrees may be harder to obtain and certainly seem to take longer to get. The titles, Academician and Corresponding Member, apply of course to the Academy of Sciences of the U.S.S.R.

Library—I visited the reading room and stacks of the library which is said to contain 700,000 bound volumes and to exchange literature with 56 countries. I saw up-to-date journals from Canada and many other countries, and I examined the card index catalogues, of which there are two, one in the Cyrillic and the other in the Latin alphabet.

Museum—The museum of the Geological Institute occupies one complete floor of the pre-revolutionary building of the Geological Survey and is divided into two parts, one of which was excellently illustrated with maps and specimens of the following 14 divisions of the U.S.S.R.: Europe, Urals, Caucasus, Volga, Mid-Asia, Ka-

zakhsan, Altai, Western Siberian Plain, Siberian Platform, Lake Baikal and eastern Siberia, Far East, Kamchatka and Sakhalin, Northeastern Arctic, and Taimyr Peninsula and the Soviet arctic islands.

One interesting exhibit was of kimberlite closely resembling that of South Africa in appearance and coming from the diamond pipes of the Siberian Platform. These are said to be Triassic in age and up to 300 meters across. These pipes are plainly indicated on aeromagnetic maps, and a well-illustrated report upon diamonds they contain has recently been issued.

Laboratories—I briefly visited the Absolute-Age Laboratory containing three argon lines, two of which handled 150 g specimens and one of which handled 1 g specimens. It was stated that the potassium was determined by wet chemical methods and that ages were not determined on specimens with less than one per cent potassium. All argons were said to be checked on a mass spectrometer which I saw. It appeared to me that the resolution of this mass spectrometer was poor in the 200-mass range, but it might be satisfactory for argon. It was stated that it was out of adjustment, and I was told that from 8-10 argon ages were determined each week. The chief of the laboratory was said to be Mrs. Polevaya, but I met only Mrs. Murina and two other assistants.

I briefly saw the Thermal Analysis Laboratory, and I was shown a new magnetic separator. It was stated that it had a maximum field of 60,000 gauss between two pointed pole pieces. The minerals to be separated are placed in powder form along a fold in a piece of paper. By moving the folded paper back and forth between the pole pieces, an excellent separation can be immediately effected between minerals having different magnetic properties.

I also saw the workshop, of which the chief was Mrs. Ivanova, but there was no time to see other laboratories. The library and laboratories were all very crowded. So, I believe, were the offices, for the main building had been erected about 1900.

Geological mapping—The excellent geological maps of the U.S.S.R. (on 1:2½M, 1:5M, and 1:7½M) of Eurasia and the detailed maps of many regions (for example, the Caucasus on 1:500,000M) are well known and were not particularly shown to me.

Because of the severe Russian winters, most field work is done in the summer, and I therefore did not meet many of the senior geologists.

Aeromagnetic work—Some of the aeromagnetic work being carried out by the Geological Institute was shown to me by Mrs. T. N. Simonenko. Apparently, these surveys were started in 1948 and are still continuing in a routine fashion, using apparatus said to be similar to that used in North America. Profiles are flown at 1- or 2-km intervals at a normal height of 200 m (rarely 400 m). Later prospecting in favorable areas may be repeated at closer intervals at 70-m heights. Most aeromagnetic work maps are plotted on 1:200,000 scale, but topographical bases do not exist on that scale for all the U.S.S.R. The magnetic profiles are plotted at scales varying from 40 to 200 gamma per centimeter on these maps, of which I was shown a sample. I also was shown a large compilation about six feet square covering much of Siberia between 58° and 66°N. and 84° and 105°E., on which the magnetic profiles were plotted on a scale of 1250 gammas per centimeter. I understood that more than one third of the U.S.S.R. has been covered with such aeromagnetic maps, especially Europe, the western Siberian Plain and the covered Siberian Shield. This work normally follows air photography and precedes geological mapping. I understood that a major project had been the aeromagnetic mapping of the west Siberian basin which contains up to 4 km of sediments. Mathematical analysis of these maps has enabled the depth of intrusions at the surface of the basement to be calculated for 5000 points. No greater accuracy than ± 15 pct was claimed for these determinations, but they supplement other methods in making contour maps of the depth of this vast and potentially petroliferous basin.

I understood that no electromagnetism surveys were being made from the air, except in an experimental fashion, but ground electromagnetic and magnetometer methods are used for detailed work.

Another use of the aeromagnetic data appears on the 1953 tectonic map of the Siberian Platform, edited by Dr. Spizharski on a scale of 1:2,500,000 in four sheets, for it shows the location of a great number of buried Triassic sills, similar to those of the Karroo basin in Africa. It was pointed out that the exploration of the

west Siberian Plain was of necessity being primarily carried out by geophysical methods because the geology was not exposed; on the other hand the Siberian Platform is being chiefly mapped by geological field work, aided by aeromagnetic surveys.

Mrs. R. M. Dementitskaya showed me the maps and profiles of the crust of the Earth which she had prepared. (It was interesting that since Mrs. Dementitskaya's English was not as good as some of the other scientists, she brought her own interpreter who translated the whole technical conversation into excellent English with great rapidity. The interpreter who had been kept out of school for the occasion was her own sixteen-year-old son!)

She had prepared a map of the world, showing the location of 208 seismic determinations of the thickness of the Earth's crust which had been culled from the scientific literature of the world and which included many determinations from the U.S.S.R., particularly in the Caucasus and east Caspian regions. Gravity and relief maps of the world had also been prepared on the same scale. From these data two graphs had been plotted showing the thickness of the crust in kilometers plotted against the values of gravity in milligals and of elevation, respectively. From them the following formulas had been deduced

$$H = 35 (1 - \tanh 0.0037 \Delta g)$$

and

$$H = 33 \tanh (0.38 \Delta h - 0.18) + 38$$

Where H = thickness, km; Δg = Bouguer anomaly, mgal; and Δh = height above sea level, km. These two equations or the graphs on which they had been plotted thus gave two values for the thickness of the crust for every point on the Earth's crust for which the gravity anomaly and the altitude were known.

From this it was possible to draw up contour maps of the thickness of the crust for the Earth and the two sets of results are said to give generally similar results. Corrections made for areas covered with sedimentary rocks was said to improve the agreement, but the principal conclusion drawn was more elaborate and elegant.

The Russian seismic data suggest that the crust is divided into an upper layer consisting of granodioritic gneiss and sediments and a lower layer of basalt. By using the two values of the

thickness of the crust, Mrs. Dementitskaya had been able to estimate the thickness of the granodioritic and basaltic layers of the crust above the ultra-basic mantle and draw latitudinal sections right around the world every ten degrees from 70°N. to 60°S. These sections have been published in the journal, *Soviet Geology*, together with a world relief map of the Mohorovicic layer. Mrs. Dementitskaya had also used these profiles to construct a series of three-color geological maps of the whole world, showing the distribution of these three types of rocks to be found at each of the 10-, 20-, 30-, 40-, 50-, 60-, and 70-km depths.

All-Union Geological Oil Prospecting Research Institute, Leningrad—(One of the two such institutes; the other in Moscow deals with that part of the U.S.S.R. in Europe, this one especially with U.S.S.R. in Asia.) There are other geophysical, industrial, and local institutes which carry on prospecting rather than research. Staff: Director, S. M. Simakov (absent); Deputy Director and Chief Geologist, Dr. B. F. Dyakov; Chief, Geology Department, Candidate S. M. Domrachior; Chief, Geochemical Department, Candidate N. M. Yurgenov. Other members of the staff whom I met were: Dr. (Mrs.) Z. A. Mishonina; Mrs. E. H. Ivanova, geologist; Mrs. O. A. Kalinina, geophysicist and chief of geophysical laboratory; Dr. E. N. Sokolov, corresponding member of the Academy of Sciences; Dr. N. J. Abrov, chief of an expedition; Candidate S. M. Katchenkov, chief of a laboratory; Mr. V. S. Moisenko, scientific secretary; Candidate O. A. Zabokritski; and Mr. A. N. Khranov, research worker (paleomagnetism).

History—This Institute was founded in 1929 and is the oldest of its type in the U.S.S.R. and was preceded only by the Geological Section of Oil Prospecting of the Ministry of Geology. The Institute employs 1500 technicians with intermediate degrees (that is, technical high school) and 400 experts with higher education, such as college degrees, including 70 candidates and 20 doctors. The Institute gives training to graduate students and awards higher degrees.

This Institute was in the building which before 1917 belonged to the Land Administration of the Department of Agriculture, which explains why there are two full-scale statues of bison in the front hall. Every year this Institute publishes 20 or 25 volumes of papers.

Regional Geology Branch—Studies geological structure of the U.S.S.R. and estimates its oil prospects. To do this, the Institute organizes expeditions which include scientists from many different fields of work together. The same expeditions may work in the north in the summer and in the southeastern regions in the winter. The Institute works in all Russia east of the Urals with large expeditions in east and west Siberia, the Far East, Kamchatka, lower Volga, between the Aral and Caspian Seas, and in Kazakhstan.

The Institute explores the major basins, making structural, facies, isopach, and environmental maps. It is carrying out a program of drilling deep exploratory wells.

I saw a map of Asia on which were the approximate locations of 35 such wells. If possible, of course, they would be sited on potential petroliferous structures. The majority were being drilled in a rough grid over the western Siberian Basin but others were proposed in several basins.

In reply to my questions, they agreed that there had probably been once connection between the ranges in Alaska and those in eastern Siberia. They also indicated that there might not have been any direct connection between the Hercynian in Germany and the southern Urals as has sometimes been supposed.

Oil Geochemical Branch—It was stated that there were about 15 laboratories in Leningrad which I did not see but of which the biggest dealt with bitumen, oil, gas, spectroscopy, luminescence, gravimetry, and isotope analyses.

Discussion on paleomagnetism—A. N. Khranov, a young man who has recently published a book on paleomagnetism, lead a discussion on that subject. He stated that in 1953 he had started the paleomagnetic investigation of sedimentary rocks to see whether the information could be useful in stratigraphy. He works in a laboratory located 30 km north of Leningrad at Kogolovo.

As a control they had started to investigate the properties of a section 300 m thick of uniform Paleocene rocks occurring immediately south of the Gulf of Kara Bugaz on the east side of the Caspian Sea. They had compared the direction of magnetization (normal or reversed) in a series of zones in nine sections, spaced at $1\frac{1}{2}$ -km intervals. They had also compared other sections

at distances up to 100 km apart in west Turkmenistan. It was stated that the fossil control was not very good and the paleomagnetism seemed to provide connections which agreed with the changes in ratio of clay to sand. They had also found that the pole had been 10° closer to Alaska in Paleocene time.

Much work had been done on sediments as old as the Ordovician in other sections. Most of this work has, I believe, been published. Mr. Khranov believed in polar drift, but he considered that the deviations between different continents were not real but were only due to errors. He explained that this Institute does not work on the paleomagnetism of igneous rocks.

Oil Production—I was informed that the oil fields (whose date of discovery are given) are arranged in the following order of production: (1) Tataria, 1950 (or 1948?); (2) Bashkieria, pre-war; (3) Kuibyshev, 1936; (4) Baku, pre-war; (5) North Caucasus, pre-war (more post-war); (6) Ukraina, pre-war; (7) Caspian-Ural-Turkmen, pre-war; (8) Emba—N. Caspian, pre-war; and (9) Sakhalin, pre-war.

No oil but some gas has been discovered in Siberia. This year it was expected that the total annual oil production would exceed 100,000,000 tons.

It was stated that there were many pipelines; for example, one with gas from the Ukraine to Moscow and Leningrad.

All-Union Scientific Institute of Geophysical Prospecting Methods, Moscow—Staff: Director, Candidate M. K. Polshkov; Deputy Director, Mr. Kudinov; Chief of Logging Dept., Dr. S. G. Komarov; Chief of Electrical Prospecting Lab., Candidate A. M. Zagarmistr; Chief of Seismic Prospecting Lab., A. N. Fedorenko; Chief of Logging Interpretation Lab., Candidate N. A. Perkov; Chief of Laboratory of Geophysical Instruments (this Laboratory, although part of this Institute is located in Leningrad), Ye. A. Riss.

At this Institute I also met the following men: Candidate A. I. Bogdanov, Chief of Geophysical Department, Russian Federal Socialist Republic; K. I. Tomenko, Crew-Chief, Turkmenian Expedition; V. A. Kornev, Geologist in Chief, Caspian Sea Geophysical Expedition.

The Institute is located in the former Princess Elizabeth Palace on Cherniakovski Street. This is a well-known building, built by the famous

Italian architect Rastrelli for Elizabeth, the daughter of Czar Peter the Great who later became Queen of Russia.

This institute is one of the older ones with 1000 workers, of whom half are graduates and 62 are candidates and doctors. I think it grants degrees.

It operates in all parts of U.S.S.R. except western Siberia (where there is a special institute related to this one) and deals with all methods of geophysical prospecting but especially those for oil and gas. Each method has a separate laboratory. It also has two field departments, for studying well-logging in Bashkieria and field methods of prospecting for oil and gas at Saratov. It has several large field parties, called expeditions (although they may work continuously for years) especially in Tataria, Caspian Sea region and Siberia. It also has branches which are complex organizations concerned with several methods.

Some of the methods and the laboratories for studying them concern electrical prospecting, magnetic methods, gravity, radar geodesy, seismic methods (two labs), analysis of data (includes geological interpretation), well-logging (several labs), physical properties of formations, perforation (several labs), and design bureaus.

I learned that they are carrying out marine prospecting in the Caspian Sea running profiles up to 200 km long with boats operating at 6-10 km/hr. Twenty-four geophones at 50 m intervals on a 1200-m cable were said to be towed and charges were said to average 5 kg. Navigation is by shoran and radar geodesy. A new dome was said to have been found east of Baku in the Caspian Sea.

They told me that they used the Rybka method of recording the amplitude of waves in terms of intensity on the record in some cases and had had good results in this way in faulted regions and for working out structures below layers of salt as in the region near the southwestern corner of the Ural Mountains.

They explained the difficulties of seismic work on shields or platforms where all the rocks have gentle dips, flat structures, and high velocities. They used aeromagnetic, telluric, electrical, and gravity methods first and then seismic methods for details. The top of the basement seems to be best found by telluric methods.

I heard some account of prospecting expeditions in the central west Siberian Platform, one

of which was equipped with seven helicopters and two airplanes and had covered 300,000 sq km in a season with gravimetric, telluric, and seismic surveys. Parties belonging to the expedition had covered as much as 100 km of line per week. I understood that the location of gravimetric points had been made from air photographs, tied to geodetic points which are located about 150 km apart. In the north I believe that these geodetic points are often at meteorological stations. On the other hand when traveling by train, I frequently saw what appeared to be the scaffolding of geodetic stations in all parts of Russia and China which I visited. I believe that the estimates of elevation may have been made by using the water level of rivers and estimates of the rate of change of elevation along the water surface.

Along the west side of the Urals are petroliferous reefs which are investigated by a complex of methods.

In the matter of logging the Institute is concerned with developing new instruments especially for radioactive and electric logging. They are developing thermally stable instruments. They have scintillation counters and use neutron sources.

They are seeking to improve their quantitative estimates of permeability and they have had success in doing this for porosity.

They have special methods of electric logging which they are continuing to develop, one goal is to find the resistivity of layers with high accuracy.

They are interested in carbonate sedimentary rocks, for which they have only so far qualitative methods.

For velocity logging they use two sources of disturbance and two pick-ups (which they said was one more source than is used in United States). They have developed field instruments for measuring velocity at single locations but their equipment for continuous velocity logging is as yet only experimental.

Central Geophysical Expedition to Tuimasi—Staff: The chief of expedition was Candidate U. N. Godin. He told me that he was 46 years old, that he had 29 years experience in oil prospecting and that he had been awarded a Stalin Prize a few years before. He expects soon to complete his doctorate. Other senior members of

the party included, H. M. Fonfayev, M. Davyshev, and M. Gerashev.

The whole expedition had 950 men and women, which was about 100 short of their full complement. Of these about 80 have higher education. The expedition also has two planes and nearly 200 vehicles including 14 trucks with six-wheel drive and 60 trace seismic recording apparatus and five trucks with 48 traces. Every part of the expedition seemed to operate efficiently.

The expedition was divided into six parties of which two made regional studies and one each studies reflection, refraction, converted, and local earthquake waves. Converted waves are those which change from P to S type on reflection. By using suitably oriented geophones of special types P-P and P-S waves are received and timed separately.

The expedition was concerned with developing methods and with carrying out regional surveys, but not with actual prospecting in the Tataria region in summer and in the Turkmenia region in the winter. Its budget was about 20,000,000 roubles a year.

I flew to Ufa near the Ural Mountains in a commercial plane and was picked up and flown to Tuimasi and back and to field parties in a four-seater YAK-12 plane belonging to the expedition. The headquarters of the expedition is in houses in the village of Tuimasi, which is growing rapidly. From there we drove along a well-paved road about 20 miles to a small guest or staff house in the town of Oktiabrsk, also greatly expanded. The whole road lies through a large oil field, producing, I was told, both from Upper Devonian and Carboniferous pumped wells (1000 to 2000 m deep) and from deeper Devonian flowing wells. This field lies across the border of Bashkaria and Tataria provinces and was discovered in 1948.

This expedition is operating over a large region, much of which I visited, lying between Chkalov (or Orenburg) and the junction of the Kama and Belaya rivers. Its tasks were stated to be:

(1) *General and theoretical*—To find connections between geophysical and geological structures; to investigate the genesis of oil and the mechanism of fault zones; to determine the geological nature of gravity anomalies; to determine the geological nature of magnetic anomalies; to find the deep structure of the Earth's crust; to

find the deep structure of geological structures and of sedimentary cover; to investigate neotectonic movements; and to determine the relations of regional structures and the spread of oil deposits.

(2) *Methods*—To develop seismic methods for determining geological structures; to develop new methods of seismic prospecting (including converted wave methods); to develop complex, regional exploration methods for mapping the surface and interior structure of the basement; to develop methods of correlating records of refracted waves where there were no clearly expressed reflecting horizons; and to develop methods of prospecting for buried structures.

(3) *Geological prospecting*—To determine the regional tectonics of the Southern Russian Platform; to map the surface of the basement in that area; and to establish the laws of distribution of oil and gas in that region, all in three dimensions.

The expedition chiefly carried on seismic work, for gravity and magnetic surveys were not regarded as research jobs and could be executed on demand by other parties. Telluric work was done for them by the Electrical Prospecting Lab of their parent Institute of Geophysical Prospecting.

A contour map of the surface of the basement has been published in *Geology of oil*, in May 1958. This map is being extended. It shows large domes and graben on the edges of which most of the smaller petroliferous structures are found. Some uplift is still going on irregularly and is studied by observing river terraces. Other information especially of the work of the parties in winter in Turkmenia and Uzbekistan was published for the International Geological Congress in Mexico City and in *Geology of U.S.S.R.*, 1958.

A major task on which the two regional parties was involved was the running of long seismic profiles. This work had been started in 1956 when 350 km were said to have been completed. In 1957, 750 km were run; in the winter of 1957-1958, 650 km, and in the summer of 1958, the program called for 1,300 km.

I flew along a line 300 km long on which were 20 firing points and along which moved three seismic recording trucks with 60 traces each. Four geophones were set together in a ten-meter square every 100 m, so that traces were obtained

from a 18-km spread every shot. By this method of continuous profiling, first arrivals were obtained for all layers down to 90 km depth.

Omitting the layer of sediments, the results shown in Table 1 were obtained. By using reflection as well as refraction data and perhaps other data said to have been obtained in the literature, the average section shown in Table 2 was suggested for the Russian Platform.

Pairs of special geophones were used at distances of from five to a few hundred km from shot points and up to several thousand km from earthquakes occurring along the Pacific borders.

Consider the case of three distinct layers of sediments resting on the basement. Waves are only converted from P to S at the boundaries between layers. In some places these boundaries are very distinct. Such would be the case if three

TABLE 1—Results of seismic studies on a typical profile

Apparent velocity (varying dip)	True velocity	Distance, shot point to critical point	Distance, shot point to first arrival	Depth of top of refracting layer for Russian platform	Interpretation of nature of layer
km/sec	km/sec	km	km	km	
6.0-6.8	6.0-6.6	...	25-55	2-7	1st granitic
5.0-7.7	6.3-7.0	25-30	96-160	7-11	2nd granitic
5.5-8.7	6.9-7.5	69-76	116-220	16-22	1st basaltic
5.5-10	7.7	75-85	150-190	26-32	2nd basaltic
					Mohorovicic Discon.
5.5-11.5	7.8-8.6	85-100	190	40	1st mantle
6-12	9.2	110-120	250	80-100	2nd mantle
7.5-9.8	9.6-?	195-200	...	...	3rd mantle

Note: The Mohorovicic discontinuity was said to give a strong record at the critical point about 86 km from the shot point.

TABLE 2—Layers beneath the Russian Platform

Layer	Average velocity	Average depth of top boundary
	km/sec	km
1 (sed)	4.5	0
2 (1G)	6.0	5
3 (2G)	6.75	10
4	5.5	14
5 (1B)	7.2	19
6 (2B)	7.75	28
7	6.3	33
8 (1M)	8.15	40*
9 (2M)	9.2	50
10	7.7	65
11 (3M)	9.8	90

* Mohorovicic discontinuity.

Converted waves were being used to measure variations in the thickness of layers of Paleozoic and later rocks by using waves refracted along the top surface of the basement.

layers, clay, limestone, and sandstone respectively, rested on the basement. The first wave to arrive will have traveled all the way as a P wave and may be represented as a PPPPPPP wave. The first three P's stand for the type of wave through the three sedimentary layers going down. The fourth P stands for the refracted basement wave and the last three for waves returning to the surface, through the sedimentary layers. This first arrival is recorded on a vertical geophone but not on a geophone which is oriented horizontally.

The only waves to be recorded on the horizontal geophone are those which are S waves in the last layer. The fastest of these is a PPPPPPS wave which will be recorded on the horizontal geophone shortly after the PPPPPPP wave reaches the vertical geophone. Slightly later arrivals recorded on the horizontal geophone will be the PPPPPSS and PPPPPSSS waves. In this way time differences between P and S waves and hence thickness can be determined for each layer below each set of geophones.

All-Union Institute for Methods of Prospecting, Leningrad—Staff: Director, Dr. G. K. Volusjuk; Assistant Director: Dr. N. I. Sofronov. There were said to be 530 workers in the laboratory of whom three were doctors and 33 were candidates and half had higher degrees. This Institute is not itself a teaching institute. It is housed in an old building.

History—This Institute was newly organized in 1955 to deal with complex methods of prospecting. By complex, they particularly mean the ways in which geological, geophysical, and geochemical prospecting can best be used together. A second object is to develop better instruments and equipment for prospecting. It is only concerned with prospecting for metals and not for petroleum, but it also deals with diamond drilling. Work is done closely with field parties all over the U.S.S.R., most of which do not belong to the Institute but which are parts of regional geological institutes.

Branches—The seven principal divisions are as follows: (1) Geophysics Division includes these five laboratories: electrical prospecting, magnetic prospecting, seismic prospecting, gravimetric prospecting, and logging; (2) New Geophysical Division has four laboratories: radioactive methods, nuclear methods, ultra-sonic methods, and airborne methods (particularly airborne electromagnetic methods); (3) Drilling Division has three laboratories dealing respectively with drilling methods such as measuring the inclination of holes, with drilling equipment and bits, and with mechanization of mining; (4) New Drilling Methods has two labs: electric spark drilling, and vibro-shock equipment drilling; (5) Design Division has two labs: design of instruments, and equipment; (6) Geochemical Division has three labs: geochemical methods, physical investigations (spectrographic), and chemical methods (silicate analyses); and (7) Complex Methods has three labs: prospecting methods for non-ferrous metals, prospecting methods for rare metals, and prospecting methods for alluvial deposits.

The laboratory also maintains a field station 52 km outside of Leningrad in the Karelian Isthmus. Most of its personnel were in the field. In all cases all field prospecting is under the direction of a single man whose duty it is to supervise and combine results whether obtained by geological, geophysical, or geochemical meth-

ods. They were especially studying areas where prospecting had proven difficult; for example, loess-covered areas. In such cases they worked in holes drilled as part of the program.

I visited a number of the laboratories but most of the personnel were absent in the field. I saw a considerable amount of spectrographic and geochemical work under way. Electromagnetic equipment and a new gravimeter were being constructed. Experiments were being carried out in drilling by producing shocks in the drill rods, caused by electromagnetic striction, and by discharging large sparks from condensers through electrodes which formed the drilling bits. These experiments were in an early stage.

A light touch was provided by a ping-pong table in a wide corridor and by a trip to the justly famous Hermitage Art Gallery in the afternoon. There Dr. Sofronov displayed an excellent knowledge of western European art, history and classics as well as languages which is not uncommon among Soviet scientists.

OTHER INSTITUTES

- (1) Arctic Institute, Leningrad (Believed to be part of the Ministry of Marine Transport)
Staff: Director, Dr. Frolov
Deputy Director, P. A. Gordienko
- (2) Department of Geophysics, University of Moscow, Professor V. V. Belousov, and Professor V. A. Magnitsky.
- (3) Institute of Geophysics, Academy of Sciences of Georgia, Tbilisi (Tiflis), Georgia

The Arctic Institute, Leningrad—Staff: Director, Dr. Frolov; Deputy Director, P. A. Gordienko; Chief of the Arctic Expeditions, M. M. Somov; Scientific Secretary: V. M. Pasetski; Dr. V. M. Driatsky, recently leader of a party on an ice island; Dr. A. P. Nickolsky, for five years at the magnetic laboratory, Quiet Bay, Franz Josef Island; and Professor Ya. Ya. Gakkel.

I met all these gentlemen except the Director who was absent and had a brief discussion concerning IGY work in the Arctic. I believe that this Institute is part of the Ministry of Marine Transport. It was mentioned that the only two seismic stations operated in the Arctic were at Heis on Franz Josef Island and at Tiksi near the mouth of the Lena River.

Professor Gakkel discussed the work which he

had published in April, 1958, in *Priroda*. He considers that the floor of the Arctic Sea and Lomonosov Ridge have a complex block structure, and he said that his bathymetric map would have to be changed again between Greenland and Iceland, as a result of a more recent voyage by the vessel *Ob*.

I was accompanied by Mr. Pasetski to the Arctic Museum, which is located in a different part of the city and which contains many interesting and original relics, including much foreign material, chiefly Scandinavian which had been presented to the Arctic Museum. There appeared to be considerable scope for exchanges between this museum and North America. Their lack of Canadian and American material is matched by our ignorance of their work which was considerable even before Bering.

Department of Geophysics, University of Moscow—Staff: Professor V. V. Belousov, Professor V. A. Magnitsky, and several other members of the staff of the Institute of Physics of the Earth.

We had only a brief visit because the University was closed. We saw some faculty offices in the Physics Building of the University of Moscow (a large six story building adjacent to the well-known new skyscraper). In the basement there is a seismological station used for training students and an excellent model experiment in which a research student had demonstrated the lack of viscosity in the Earth's core by studying the fall-off in amplitude of diffracted waves in the shadow zone.

The mantle was represented by a thick solid sphere about 18 inches in diameter, filled with water representing the core. Ultra-sonic waves simulated earthquake waves.

Geophysical Institute of Academy of Sciences of Georgian Soviet Socialist Republic, Tbilisi (Georgian name; formerly Tiflis, Russian name), Georgia—Director: Dr. Tsvetvadze. This Institute is housed in a relatively new building near which are being erected other academy buildings. It has the following divisions: Gravity, Seismology, Electrometry, Magnetometry, Ionosphere, Cosmic Rays and Physics of the Atmosphere.

The last is making special studies of the hail, the effects of which on local vineyards is serious.

I chiefly visited the Seismology Division with its chief, Dr. A. D. Tskhakaya. A map of the seismicity of the part of the U.S.S.R. south of the Caucasus shows three principal centers of activity: (1) at Sochi on the Black Sea, (2) in Armenia near Mount Ararat, and (3) along the line of the Caucasus Mountains. There are two weaker parallel lines to the north. These centers of activity move about. There are 23 seismic stations already operating in this region and 16 more are projected.

This academy publishes its works in two editions; in Georgian and in Russian. Georgian is a more ancient language with a wholly different alphabet.

The excellent library contained long files of many journals, among which I noted *Proceedings of the Royal Society*, *Nature*, *American Journal of Science*, *Annals de Géophysique*, *Journal of Geophysical Research*, and *Geophysics*.

A group of Georgian geophysicists very kindly showed me something of the geology and scenery of the Caucasus Mountains as far as the pass on the Georgian Military Highway from Tbilisi to Ozdjonikidze.

Part 2—China

INSTITUTES OF THE ACADEMIA SINICA OF THE PEOPLE'S REPUBLIC OF CHINA

The Academia Sinica is the governing body for much scientific work in China. The President is Kuo Mo-Jo and the Secretary Pei Li-Chang to whom I am indebted for arranging my trip.

Among the fifty institutes which it controls according to *The World of Learning* are the following:

Institute of Geophysics and Meteorology, Peking, Director: Chao Chin-Chang*

Central Geophysical Observatory, near Peking

Institute of Geology, Peking—Director: Hou Teh-Feng (former Director: Lee, J. S.?)
Deputy Director: Chang Wen-Yu

order Doe John-James, but sometimes in western style John James Doe. A hyphen may be used to indicate the order, but I have omitted it in some cases in which I was uncertain. I also had trouble determining the correct titles and have left all out of this list. In China, I met geophysicists and geologists with degrees (usually Ph.D.'s) from the Universities of Göttingen, Oxford, Yale, Columbia, McGill, and California Institute of Technology.

* Chinese names are normally written in the

Laboratory of Vertebrate Paleontology, Nan-king, Director: Yang Chung-Chien

Laboratory of Peking Man, Choukoutien, Director: Lan Po Chia

Lanchow Branch of Academia Sinica, Lanchow, Director: Tung Chieh

Lanchow Geophysical Observatory, Lanchow, Director: Chu Chan-Hsiung

Sian Geophysical Observatory, Sian

Institute of Geophysics and Meteorology, Peking—Director: Dr. Chao Chin-Chang; Vice Director: Dr. Chen Tsung-chi; Senior Research Scientist: Dr. Lee Shan-Pang. All spoke English and Dr. Lee had certainly visited the United States. I gathered that the other two had studied in Germany.

It seemed that the Institute had about 100 employees of all ranks in Peking, but it directs the work of many others because Dr. Lee, for example, had 150 seismologists working for him in stations scattered about the country. Many of the scientists were college graduates, but it seemed also possible for a bright apprentice to undertake research and obtain a bachelor's degree or diploma later. I think that the Institute has research students and can award candidates degrees (roughly equivalent to Ph.D.'s), but I was never quite clear on this point, perhaps because the policy is changing. Some such institutes in China as in the U.S.S.R., which are not related to universities, certainly do have the power to grant higher degrees.

This Institute is located in a newly developed area of northwest Peking, in which are concentrated a great collection of new institutes, universities, and similar buildings. Over a large area there is tremendous activity to replace the former fields of vegetables with new laboratories and offices and with dormitories for the workers employed in them. It seemed quite possible that as many as 100,000 scientists and students might soon be working in that area. The institute which I visited was only a very tiny part of this cultural center, but its one new permanent building was typical of nearly all the other new university buildings, so I shall describe it.

It is well-built of grey brick with a tile roof, three stories high. Few buildings, except hotels, have elevators, so that they are rarely more than four stories in height. Inside there are three stairways connecting central corridors which run the length of the rectangular building. On each

floor and in the basement are a couple of dozen rooms. The building is plain but well-built with white plastered walls, terrazo flooring, electric lights, running water, a few coils for steam heat, and doors and windows that open and shut properly. The senior scientists have bare and simple offices of their own, equipped with the necessary furniture and plenty of books. Laboratories have good benches, black boards, sinks, adequate outlets for electricity, water, and gas. These buildings are in fact entirely satisfactory for their purpose, but without any frills.

Housed in this fireproof building is an excellent library, of which they were obviously proud. They pointed out that they had the responsibility of answering a lot of questions upon which large expenditures might depend; for example, the construction of dams, bridges, or buildings. They had acquired this excellent library over the past 30 years.

By counting shelves, I estimated that the reading room held about 400 current journals on geophysics and related subjects. It was impressively complete and up to date, having, for example, four Italian geophysical journals, five Japanese ones, besides everyone of the well-known journals published in English, French, and German. I also went carefully through the stacks and opened a variety of the volumes there. The sets of all important geophysical journals were complete and there were many marginally related publications like *Proceedings of the American Society of Civil Engineers* and geological journals. The library and its indexes were all in three parts, for there were large Russian and Chinese sections, as well as that for the western languages. I was told that there are about 50 Chinese scientific journals at present, but that the number is increasing and that all may be obtained by subscription. From my own observation, all but the popular type have at least abstracts and often whole articles in Russian or in some western language.

Although this library was larger than most which deal with only one field, good libraries were to be found in every institute and university I visited. Back numbers of the more widely read journals are easily obtained in China, for they have been multilithed, and I repeatedly saw copied versions of some of the standard American, English, German, and Russian journals and common textbooks.

I was also taken through the work shop where they make some of their own instruments. Crowded into a temporary building were about 50 men and women who were operating about 20 lathes, a milling machine, a planer, and some other tools, mostly of Chinese manufacture. Each operator was training a young apprentice. The chief mechanic explained to me that for two months they were doing no other work except making 30 more lathes which they would soon need and could not otherwise obtain. Pieces of one of the standard Chinese lathes were being copied all over the shop.

This Institute of Geophysics and Meteorology had been formed, I was told, in 1928 as an Institute of Meteorology, but having much the same functions as today. It is concerned with meteorology, seismology, geomagnetism, and also, I was told, with geophysical prospecting although I saw none of the last. In 1935, I was told, there had been only 50 meteorological stations in China and only two seismological stations. (One was at Shanghai, founded by Jesuits, and the other at Nanking.) They stated that there are now 1500 meteorological stations reporting four times daily through local centers of which 400 are pilot-balloon stations and 70 are radiosonde stations but I did not see these. They make daily, three-day, and monthly forecasts and were working towards mechanical forecasting by the use of computers.

They also said that they had 30 seismological stations. This seems reasonable because in Moscow they said that they received bulletins from 23 Chinese stations and that 16 more were contemplated. I saw three of them and they offered to show me others. The Chinese also have temporary mobile stations. In the vaults and scattered around this Institute, I saw many of the Chinese seismographs. They are of six main types. There are three varieties of the so-called 1951 type, a simple instrument designed by Dr. S. P. Lee for the purpose of getting stations started quickly when he was told to do that in 1951. There are small Russian Vegik, standard Russian Kirnos, and high sensitivity Russian Kharin seismographs, all of which have been copied and are now made in China. They have also built a portable instrument operated from batteries which can be used for preliminary investigations. This has high speed visible recording.

The chief research project so far executed in

the seismological division arose from the desire of government for maps indicating the frequency and intensity of the earthquakes to be expected in every part of China, so that suitable precautions might be taken in building dams, bridges, buildings, railways, and so forth. As is well known, many parts of China, but by no means all parts, have severe earthquakes from time to time. Since only two seismograph stations had been operated for any length of time, the instrumental records were inadequate except in those regions where earthquakes were so numerous that useful data had been obtained during the very few years since the network of new stations had been installed. By good fortune these data were adequate in the mountainous parts of southern and western China, which are most active seismically and most thinly settled. For the plains where earthquakes may be dangerous but are less frequent, Dr. Lee obtained the services of 150 historians who in two years reviewed the whole literature of China and found about 10,000 useful references to individual earthquakes occurring between 1189 BC and the present. The two methods are thus complementary and cover all China.

By a careful analysis of these very imperfect and varied data, Dr. Lee has prepared the required maps in preliminary form. Two out of the three volumes of his remarkable report have already been published and favorably reviewed in the *Bulletin of the Seismological Society of America* (by E. R. Hope, 48, 194-198, 1958). He showed me his work on the final volume. I also saw most of the laboratories and other projects in progress in the Institute, except for those being done in the field.

Central Geophysical Observatory, near Peking

—This is a new station with seven or eight brick buildings surrounded by a wall and situated at the foot of the mountains 20 miles west of the center of Peking. The three non-magnetic buildings for geomagnetism were opened in 1955, the seismic station with its deep vaults in 1957, and the cosmic ray building which I did not see and the solar observatory in 1958. There are also dormitories.

Everything which I saw was working. In the seismological station were five young scientists who shared with the Institute in Peking responsibility for controlling all 23 permanent seismological stations and for checking their records

and preparing a bulletin of Chinese earthquakes. This is sent only to China and U.S.S.R.

Institute of Geology of the Academia Sinica, Peking—In Peking there are two Institutes of Geology; one under the Ministry of Geology which has charge of mapping, and the other under the Academy which is devoted to problems. I was told that the first has much of China, except Tibet, mapped on one millionth scale and will shortly publish a new edition of the geological map of China (last published in 1948) on a scale of one to four million. I did not visit that Institute, but I visited the Institute of Geology which is under the Academia Sinica and met the vice director, Dr. Chang Wen-Yu. I think that the well-known Dr. Lee, J. S., was the director, but he has perhaps retired. The chief paleontologist is Dr. Yang C.-Y.

The Institute is housed in what I was told was the old geology building of the University of Peking. It was very crowded, but they expect to move next year to new buildings in the Academy area, northwest of the city. In the Institute I was shown manuscript maps of China on the same scale of one to four million of tectonics, of quaternary geology, and of modern tectonic movements. This Institute expects to publish them soon.

In the Institute I saw six chemical laboratories, of which one was devoted to total rock analysis, another to the study of rare earths, and another to the study of germanium, gallium and indium—metals useful in transistors. I also visited several spectograph, x-ray, polarimeter, flame photometer, microscope, and balance rooms, in which was a great variety of equipment from Japan (Shimadzu), Germany (Zeiss), Czechoslovakia, and the United States (for example, a Geiger-Mueller counter and pulse visualizer, type 322, serial 585, made by Cyclotron Specialties, Moraga, California).

I also saw the mineralogical and petrological labs with many interesting and economically important specimens; but the engineering geologists and stratigraphers were all in the field. One man was doing a good research job on the distribution of phosphates (which can be used for fertilizers) in Chinese rocks.

They were unhappy about their library which was small because they had no room and because in the expansion other institutes had got most of the old books.

Several of the geologists displayed detailed knowledge of topics in recent western literature. They asked me about new books, but I could only suggest two very recent ones which they did not have.

Laboratory of Vertebrate Paleontology, Nanking—I did not visit Nanking, but I heard that this institution is the parent body for the Laboratory of the Peking man.

Laboratory of Peking Man, Choukoutien—About 500,000 years ago, Peking man, one of the best-known early humans, was living in caves in the side of some limestone hills beyond the ancient Marco Polo bridge, southwest of Peking at a place called Choukoutien. During excavations there some thirty years ago, five skulls and many other bones and tools of this early race were discovered. Unfortunately, during the Sino-Japanese war, the cave was devastated and the skulls were taken away and lost. One of my companions believed that they might be in the United States, but a more likely view is that they were sunk in a small ship which was endeavoring to take them to safety.

Work has now been resumed by 60 men under the direction of Dr. Lan Po Chia and a young woman archeologist. Five more teeth have recently been found. Two-thirds of the cave still remains to be dug. Three one-story brick buildings have been built to act as museum, office, and dormitory; railings and notices surround the excavations; trees have been planted. Quarrying has been stopped in other quarries nearby, caves containing stalactites are being opened to the public and steps are being taken to turn the area into a scientific park or monument.

The building program is disclosing many other sites. At Sian I was shown a Neolithic village in process of careful excavation. These sites have geophysical interest as they often record changes in river or sea levels during periods which can be measured.

Lanchow Branch of the Academia Sinica, Lanchow—The chairman of the local branch of the Academia Sinica, Dr. Tung Chieh, showed me his buildings. He said that the site covered 863 Chinese acres and he showed me a model on which there were 35 large buildings in which it was planned that 15,000 people would work and an additional 25,000 children and relatives would also live. At present they have 900 workers but expect 1500 by the end of this year. They re-

cently had a drive lasting two months to try to get more workers, but only recruited 300 of the 500 wanted, so they are training the relatives of present workers. These 300 included primary school, secondary school, and college graduates. Many of their workers attend classes in the morning and work at their jobs in the afternoon. Both the librarian and the chemist in the Geology Division (who is the only college graduate in his laboratory) wanted more college graduates.

Late in 1955 building was started and by 1957 the library was the first building completed. Two research buildings and two dormitories have been finished since then, and the building to house geological research is under construction. Geological research will occupy 11,000 m² of floor space next year.

Geology is temporarily housed in one of the existing buildings. Most men were in the field; others were preparing material for the new buildings. Many new rock specimens show that Kansu province is rich in minor metals for I saw celestite and wolframite as well as many base metal ores, optical rock salt, and oil-rich sediments. The geology library had about 200 periodicals, of which only about a quarter were western, but there was an excellent collection of books. There were also two chemical labs and some Russian spectrographic equipment.

I walked through the main library building. It chiefly contains stacks as the books will be taken to other buildings to be studied. My private observation, indicating that the library had two wings each five stories high, that each story had 40 bays of 12 bookcases and that the bookcases were 7 shelves high, each shelf holding from 25 to 40 books, agreed perfectly with the statement that the library was intended to hold a million books. I also thought that the statements that there were already 130,000 volumes and that 2600 science journals were received seemed to be correct.

All agreed that Kansu was formerly regarded by the Chinese of the plains as a poor and miserable place, dry and dusty in summer; cold and extremely poor in winter. They pointed out to me that on the hills around Lanchow, grazing had been stopped; small trees were being planted to reduce the dust and indeed the hills were turning green. A great deal of coal had been discovered and the siding to a mine was pointed out to me.

Irrigation had been greatly increased, and they stated that about 50 miles from Lanchow, they were proposing to divert the whole Tao River (150 m³ a second flow) and irrigate 20 million more acres. They also expect to dam and control the Yellow River. They were clearly trying to justify Lanchow's ancient name, 'The Golden City of China.'

Lanchow Geophysical Observatory, Lanchow—I visited the local geophysical observatory which had been built for the program of the International Geophysical Year. Since it was in the hills at the end of an appallingly bad track, it was evidently rarely visited. Eleven people work and live there under the direction of Chu Chan-Hsing, and they have good new buildings and a geophysical library of recent periodicals and books which was surprisingly good for so new and so small and so remote a station. The seismological vault was equipped with complete sets of 1951 type, Chinese Kirnos, and Chinese Kharin instruments, while the geomagnetic building had a temporary set of Askania instruments. By 1962 they hope to have additional buildings and to start an institute with the task of predicting of earthquakes.

Sian Geophysical Observatory, Sian—In the grounds of the Northwest University is a building devoted to Seismology and Meteorology. I visited the three rooms of the former. One room which contained radio equipment and a large clock of Chinese manufacture was used for interpretation. A second room contained two sets of two horizontal seismographs each for recording large earthquakes. They recorded on smoked paper drums and were probably the 1951 type 1 and 1951 type 3 instruments. A darkened room contained a set of three Kirnos instruments of Chinese manufacture. All were operating and I was told that after preliminary examinations the records of important earthquakes (if not all) were sent to Peking.

UNIVERSITIES OF THE

PEOPLE'S REPUBLIC OF CHINA

Those which I visited and of which I saw departments of geophysics or related subjects were:

Peking University, Peking
Northwest University, Sian
Lanchow University, Lanchow

Peking University—I visited this, the senior university in China, which is situated in and around a fine old campus, built in the palace-style about 50 years ago and situated perhaps as much as 15 miles west of Peking on the outer border of the new academy area. I believe that Peking University was formerly in the city proper, that its former buildings now house institutes and perhaps the China People's University, while its new campus once belonged to some other university, probably Yenching University.

I met the director of the Department of Geology and Geography, Dr. Hou, T. F., and the Professor of Geophysics, Professor Wang, S. T. C., who is in the Department of Physics. They said that the Department of Geology had been transferred to the Institute of Geological Prospecting when it was formed and that geology was in the process of being built up again. They also apologized for the absence of the staff who with their students were still engaged in summer field work in various parts of China on those practical problems which the central government required.

I was told that in China there are now 200 universities and colleges which had about 480,000 students; that of these, more than 30 universities, colleges, and teaching institutes were in the Peking area, with an enrollment of about 150,000 students. In Shanghai there were nearly as many. The University of Peking has over 10,000 students, which seems a reasonable estimate from what I saw of the size of the campus. Close by is the Tsinghua University, which is larger than the University of Peking, but which trains engineers. Other local universities mentioned were Peking Teacher's College, Peking Agricultural College, and China People's University, each of which also have over 10,000 students. The last is situated in the old part of the city and gives courses suitable to its location, such as journalism. It had been the policy to locate most of the universities, academies, and institutes in this northwestern part of the city, but this was being changed and henceforward new institutions would be scattered elsewhere.

At college, students must learn one foreign language fluently and may start to read a second. These are generally English and Russian, but may be French, German, or Japanese. Post-graduate students must learn two well. All the university students in China get free tuition, free

dormitories, and free medical services. They have to buy food, clothes, and books but may receive scholarships for this purpose. I believe that students each get about two square yards of dormitory space, but there may be double or triple bunks. I think that professors get about 30 square yards for a family.

In spite of the expansion in the high-school system, the program is not yet balanced and there are not enough school graduates to fill all the places available in all the expanding universities.

The undergraduate course, leading to the degree or diploma, is this year being increased from four to five years, so that there will be few graduates in 1959.

The number of hours of teaching was at the same time, I was told, being reduced from 30 to 26 hours per week, but this would not include time for political meetings and manual labor. Freshmen were said to get 180 hours on political subjects, with two hours a week thereafter.

After walking around the campus, I was shown a model of it which corresponded with what I had seen. On the model I counted about 100 large buildings. About one third of these buildings had belonged to the old campus, and about one third were new; five, including a main library, were under construction and 29 were planned. There were many more smaller buildings, including individual houses for some senior professors.

I was told that the library had 2,000,000 books, of which one quarter were in foreign languages and that the university had 300 foreign students from 24 countries; also about ten professors who taught languages from Russia and others from Egypt, Indonesia, and other countries. I believe there is one Canadian there, but it was not so stated at the time, and I did not meet him. I think that most of the foreign students in China are at this university.

In the Department of Geology and Geography there were said to be about 400 students last year, but 600 are expected this year. There were said to be 40 faculty members and 11 graduate students, but these numbers referred only to the Geology Division. This department has a summer break one month longer than the rest of the university for organized field work and, therefore, their two semesters last from late October to February and from February to early

June. The program may be reformed again soon. The Department at present shares a building with chemistry, but I saw that it had good geology laboratories and was told that there was a good departmental library.

Geography is divided into three divisions: Physical and Economic Geography and Geomorphology. It is mostly concerned with planning. Geology is divided into the seven usual specialties in all of which, except paleontology, students must take mathematics, physics, and chemistry courses.

I visited the physics department which is housed in one of the old buildings, where it seemed to be crowded, but there were more students present and better equipment than I saw in other universities. I saw that the departmental library was good and had about 50 Chinese, 50 Russian, and 150 western physics journals.

The only geophysics courses given in this university are for geologists. Geophysics is housed in two small buildings and has at least one truck equipped for seismic prospecting. A class of students were constructing electrical prospecting apparatus.

Northwest University, Sian—I met the Vice President, Dr. Chang Po-Shen who is a geologist; the head of the Department of Physics; the Professor of Quarternary Geology, Professor Wang Yung-Yu; and another geologist. I was told that this university had its origin at the beginning of the Sino-Japanese war when three universities from Peking established a united university of Chengtu. After that war, it had been divided again and had come to Sian to form what was at that time the only university in Shansi province. Nevertheless, it had at first been poorly housed and had only 700 students. Now it has 50 professors, 250 other teachers, and 3000 students in the following ten departments: Mathematics, Physics, Chemistry, Biology, Geography, Geology, Law, Economics, History, and Chinese Literature. This year they expect 900 freshmen, of whom only 300 will be from Shansi province; the other 600 will be from all parts of China, but especially Honan and the Yangtze Valley. Although the four high schools in Shansi eight years ago have now been increased to 12 and there will be 18 next year, the number of qualified matriculants does not fill the four 'comprehensive universities' now in

Sian—this university, the Northwest Industrial University, the College of Architecture, and the College of Commerce.

At present only a quarter of the high school graduates have high enough marks to qualify for college, but all who do qualify can attend because students need to pay only for food, books, and clothes; 70 per cent receive subsidies or scholarships to cover these expenses.

The student's choice of courses was said to be limited only by the quotas set for the several departments. On arrival, the students list the departments in order of preference and take entrance exams according to the results of which they are placed. The course is four years long, and no graduate work is done.

When the students graduate, the university has lists of jobs on which they are required. Each student writes a report explaining his preferences, and then in a public debate and discussion, it is decided which job is best suited to which student. 'This is democracy mingled with centralism.'

The university has a building program which is keeping pace with its expansion. This year 500 more students are expected. There are, among others, already a good building for physics and geology, a very large U-shaped one in which biology, geography, and literary studies are housed, some old buildings for chemistry, at least two large new dormitories, and a new five-story library, perhaps 200 feet long, that is nearing completion.

I visited the building for physics and geology. On the ground floor were several laboratories devoted to optics, the speciality of the President of the University. There were laboratories in which some members of the staff studied the viscosity of metals. The physics library had at least 120 current periodicals, perhaps one quarter in Chinese and the rest chiefly in English or Russian, although I noticed other languages. In the laboratories Chinese and English textbooks were in use. Most of the instruments, especially the commoner ones, had been made in China, including meters, resistance boxes, electronic parts, batteries, C.R.O.'s, and a big power supply for an arc source. Much of the optical equipment was from East Germany, the electronic instruments from Hungary, and the spectrographs from Japan. I saw one chemical balance from the United States and a little Russian equip-

ment. There were charts and a table of elements printed in Chinese.

On the second floor were two large rooms devoted to geological specimens arranged in a normal academic fashion in show cases. There was a reasonable library containing long sets of many standard geological and geophysical journals and much Russian literature. I was told that most students read English, Russian, and German, and all the professors understand and evidently read English, even if they did not speak it fluently.

Lanchow University, Lanchow—I met the Dean, Lu Yun-Ju, Professor Hsu Kung-Ou, the head of Physics and Professor Li Wen, the head of Geography.

They told me that the University, which was founded in 1946, was the first in Kansu and that it now had a staff of 700, and 2300 students. They had only moved to their new site opposite the branch of the Academia Sinia recently and had only three buildings besides dormitories, but that they expected to have two more, including a library, in 1959.

The University teaches only mathematics, physics, chemistry, biology, geography, Chinese literature, history, and economics. There were about 300 students taking literature and smaller numbers taking history and economics, so that there were 1850 science students who all took courses in physics, although only 450 of them were majoring in physics. The course is being changed from four to five years. Students do voluntary labor for one-half day a week.

There were 200 students and 45 faculty in geography, which includes work which is really geology and geophysics, as the only classes were called physical geography and geology. Most of the staff and students were out doing field work, especially upon soils, land use, and hydrogeography.

As usual they have fewer students than they want, and have been recruiting elsewhere, for example, 50 from Shanghai were expected to enter in autumn 1958. There are no foreign professors or students at the University, the latter would go to Peking. Athletic and basketball meetings have been begun; the faculty as well as the students can compete.

I went through a dozen labs in the new physics building and found them to be particularly well equipped, having plenty of instruments, a dozen

air conditioned booths for teaching optical experiments, and very good facilities for growing large metal crystals and studying their magnetic and other properties. The department has perhaps 80 journals and a good library.

The Geography Department shared the Physics Bldg. Its laboratories showed that the chief studies were geology, meteorology, and planning. There was a large stock-room full of standard meteorological equipment including rain gages, anemometers, barographs, and a four-inch Zeiss telescope. There were ten large relief models, some of local irrigation schemes made by students.

INSTITUTES UNDER THE MINISTRY OF GEOLOGY

Institute of Geological Prospecting—I met the Vice President, Chung, C. T.; the professor of geophysics, Chow Ka; and the professor of mineralogy, Shu, L. H. I believe that Professor Yuan, F. L., a Columbia graduate whom I had met elsewhere, is also on the staff. Altogether there are about 30 older professors on the staff and all the rest are tyros. It is the only institution of its type in China. It was founded in 1952 and now has, I was told, 6000 students and a faculty of 600, but it is still expanding and the enrollment this autumn may have reached 7500.

The course is five years and there are six departments or faculties; Geological Surveying, Geological Prospecting for Minerals, Prospecting for Petroleum and Natural Gas, Geophysical Exploration, Hydraulic and Engineering geology, and Mining Geology. There are also short courses (night and correspondence) and training is given to technicians. In spite of the great pressure of teaching and expansion, they had begun research and publication of results.

Apart from the Mining School which I did not visit, the Institute was housed in six very large new brick buildings, in two large brick dormitories and in many small temporary one-story brick huts, altogether more than 30 buildings, they said, of which the oldest is four years old. Two other large buildings are being erected very quickly, and they hope soon to get a library building. These buildings are in the vast area devoted to new science buildings on the northwest outskirts of Peking. This Institute has plenty of room for expansion, but immediately around the campus they pointed out two central

heating plants with tall chimneys, the mining buildings marked by a full-size head frame and hoist over a practice shaft, and the groups of buildings of large medical and aeronautical institutes.

I went through the geology and geophysics laboratories, although most of the staff, students, and equipment were still in the field. In the geology museum I estimated that there were some 7000 specimens, most of them recently collected in China, but some to be seen in laboratories all over the world. They were arranged in more than 20 small rooms, all of which I visited, and all of which were open to and were being used by students. Each room was devoted to one subject in what seemed to me to be a practical manner. I believe that the students were likely to get a better grasp of subjects illustrated by a few hundred related specimens arranged in one room, than they would have got if all the specimens had been put in one big display.

In the geophysical labs the equipment was ordinary, but I was surprised at its abundance, often ten sets of a laboratory experiment, of which a large North American university would be content with one. They had some electrical and seismic prospecting six-wheel trucks outside.

I was also in some of the chemistry labs which appear to be well equipped with benches, balances, spectrographs, and polariscopes. Both of the latter types of instruments were in use, one of them I was told for two shifts a day on practical analyses.

The students of what I was told were in a three-week short course in soil analysis were in the building. They were technicians who were

being taught only ten specific tests which they could make in a routine way.

The shops rather surprised me. Not only was there a machine shop in which about 30 boys and girls were working with eight Chinese lathes, a milling machine, and a planer, but there was also a foundry, forges, welding equipment, compressors and a mechanical hammer. All were sparsely equipped, but they told me that the students were constructing a drilling machine and a pile driver, making their own castings.

Conclusion—While leaving China, I stopped for a few hours to change trains in Chengchow and in Canton. In both places I was driven past a considerable number of buildings belonging to universities and institutes, but I did not enter them.

From Canton I took the train to Hong Kong, thus completing a rail journey across Eurasia. I stayed with a Canadian doctor who had spent his life as a medical missionary in China. He showed me the University.

I flew to Taipei and Taiwan and was very kindly received as a guest of the Government of the National Republic of China. I was shown the laboratories of the Academia Sinica outside Taipei; several meteorological, ionospheric, and seismological observatories, university departments and seismic prospecting parties, but the work of these institutions is well-known and readily accessible, so that it is not my object to describe it.

Again I want to thank all who made possible these pleasant and fascinating visits, not least my interpreters. I should also apologize again for the mistakes which I feel I have almost inevitably made in understanding or reporting all this diverse work.

Reviews

HENRI TERMIER and GENEVIÈVE TERMIER, *L'Évolution de la Lithosphère, I, Petrogénèse*, Masson et Cie., Paris, 653 pp., 14 tables, 40 figures, 54 plates. 1956. 8000 Fr., approximately \$24.00.

Many of those attending the XIX International Geological Congress in 1952 had the good fortune to meet, for the first time, the spirited geological team of Termier and Termier, as they were then at the University in Algiers. For me there was also the unforgettable experience of finding myself seated next to Henri Termier at an improvised banquet table in Taménassat and listening to him tell of their work and their working schedule. At that time, the first volume (*L'histoire géologique de la biosphère*) of their four-volume treatise of geology had just been published and was on exhibit at the Congress. This, the second volume, appeared in 1956.

The book is in two parts. The first part, entitled *Généralités*, considers the origin of the Earth, atmosphere and oceans, energy in the Earth, crystallization, rock-forming minerals, the elements and their abundance, radioactivity, and finally a discussion of the age of the Earth and its measurement. The second part of 450 pages plunges headlong into petrology and petrogenesis, and after a brief preface on the relation of zones of weakness of the Earth's crust to orogeny, presents chapters on classification of eruptive rocks, magmas, volatiles and fluids, volcanism, sima, sial, granite and granitization, volcanism in orogenic zones, convergent rocks, and exotic rocks.

The discussion of classification is of necessity brief, but it is in this chapter that the call is sounded for metasomatism to come to the aid of many rocks and explain their origin. "Convergent" rocks have been well known for a long time, as well as the fact that they may have different origins, and not all of them should be laid at the metasomatic doorstep. Table IV is interesting in outline, but I refuse to subscribe to a delimitation of 100–73.98 pct SiO_2 for peracidic rocks, 5–4.5 pct $\text{K}_2\text{O} + \text{Na}_2\text{O}$ in diorite, or many others.

The chapter on magmas goes into differentiation, open and closed systems, rheomorphism, and interaction between magmas and enclosing rocks. Ensuing chapters deal with volcanism and volcanic products. From there on, the discussion and elaboration of metamorphism, metasomatism, and granitization occupy pages 317 to 508. Numerous examples are drawn from the literature, but it is unfortunate for the reader that only one side of the story is given. One of the most striking examples is that of the well-known Bushveld Complex in South Africa, which in 1949 was interpreted by van Bijlron (although he was not the first to do so) as representing metamorphosed Pretoria sediments rather than an igneous intrusion. Anyone who has read van Bijlron's paper will be greatly disturbed

by the complete lack of reference here to the succeeding twenty pages of pertinent discussion, and particularly the points set forth so lucidly and carefully by Truter and Lombaard, both of whom are well qualified to speak on the area. The tillites of the Mt. Fitton area in South Australia are another case in point, although an alternative hypothesis by Chinner and others was probably not then available to the authors.

The volume contains 54 plates, most of which are photographs; 40 figures, of which 17 are maps; and 14 tables. The illustrations are excellent and well reproduced. The sections and maps taken from other publications are for the most part redrawn to good advantage. The photographs taken by the authors are particularly fine, and many are excellent examples of features in localities not commonly visited and therefore not usually seen in other books.

The index I consider rather inadequate in view of the breadth of the subject matter. There is not much point to indexing the name of every author cited in the text if the topics cannot be fully and properly treated. It would appear that words throughout were picked with no attempt at co-ordination of ideas or subjects. Subvolcanic intrusions appear under 'subvolcaniques' but not under 'intrusions' and the same is true of hypabyssal intrusions. Intrusions are indexed to pages 255 and 474, and yet there are many more discussions of intrusions than appear on these two pages. A scheme of three different styles of type has been used to distinguish authors (small capitals), elements, minerals, and rocks (italics), and topics and places (Roman), but certainly the users of this book hardly need to have these distinguished for them! And inevitably such schemes break down occasionally; Adamello is not an author, and neither is Davos. Bibliographic references are given at the end of each chapter, and a useful index to them is provided on pages 641–642.

But these are the trifling parts. The book in its entirety makes good reading and as with a dictionary, one finds oneself looking up topics to see what is given about them. The authors have a wide familiarity with the literature from which they have drawn, even though with such a decided slant toward their own ideas that one immediately feels that there are more unsolved than solved problems.

Marjorie Hooker

ADA SWINEFORD (ed.), *Clays and Clay Minerals, Proceedings of the Fourth National Conference on Clays and Clay Minerals*, Nat. Acad. Sci., Nat. Res. Council, Pub. 456, vii + 444 pp., Washington, D. C., \$6.00.

This volume contains a preface by Grim and

Frederickson, 42 full papers and five abstracts. The titles of the papers are listed below to show the diversity of the interests of those studying the clay minerals:

Guide to field trip of Fourth National Clay Conference, Clay minerals in sedimentary rocks, J. C. Griffiths, T. F. Bates, and H. W. Shadle

A new method for preparation and treatment of oriented aggregate specimens of soil clays for x-ray diffraction analysis, Earl B. Kinter and Sidney Diamond

Methods of preparation and control of clay mineral specimens in x-ray diffraction analysis, I. H. Milne and C. M. Warshaw

Correlation of paper-coating quality with degree of crystal perfection of kaolinite, Haydn H. Murray and S. C. Lyons

The green compression strength of natural bentonites, W. F. Bradley

The colloid science of silica and silicones, Ernest A. Hauser

Synthesis of clay minerals at low temperatures, S. Henin

The structure and morphology of a kaolin clay from Les Eyzies (France), G. W. Brindley and J. J. Comer

Shapes of halloysite particles in Japanese clays, Toshio Sudo and Hiroshi Takahashi

Recent x-ray structural work on serpentine minerals, J. Zussman

Hydrogen-deuterium exchange in clays and problems in the assignment of infrared frequencies in the hydroxyl region, Della M. Roy and Rustum Roy

Dehydration of monoionic montmorillonites, R. A. Rowland, E. J. Weiss, and W. F. Bradley

Comparison of a natural bentonite with its synthetic analogue, L. B. Sand and M. S. Crowley

The mechanism of dehydration of Mg-vermiculite, G. F. Walker

The illites from some northern Ohio shales, Bruce W. Nelson

A study of the hydrothermal reconstitution of the kaolin minerals, Rustum Roy and G. W. Brindley

Reactions of molten salts with layer-lattice silicates, Joe L. White

Spanish investigations on clay minerals and related materials, J. M. Albareda

Clay-mineral research in Belgium (1945-1955), W. Dekeyser

Summary of clay-mineral studies in Germany, 1954 and 1955, Ulrich Hofmann

A study of an interstratified illite-montmorillonite clay from Worcestershire, England, Douglas M. C. MacEwan

Contribution to the study of sepiolite, II, Some considerations regarding the mineralogical formula, J. L. Martin-Vivaldi and J. Cano-Ruiz

Contribution to the study of sepiolite, III, The dehydration process and the types of water molecules, J. L. Martin-Vivaldi and J. Cano-Ruiz

The bentonites from the volcanic region of Cabo de Gata (Almeria), J. Martin-Vivaldi, J. Cano-Ruiz, and J. M. Fonboté

Clay mineral work proceeding in Japan, Toshio Sudo

Clay mineral research in Australia, A. J. Gaskin and G. F. Walker

Forces between suspended bentonite particles, H. van Olphen

Electrokinetic phenomena in colloidal clays, D. T. Oakes, and Emil J. Burcik

Viscosity studies on dilute clay mineral suspensions, W. H. Wood, W. T. Granquist, and J. M. Krieger

Effect of wetting agents on the deformation behavior of kaolinite-water systems, W. C. Ormsby, R. M. Witucki, and W. A. Weyl

Intracrystalline swelling, cation exchange, and anion exchange of minerals of the montmorillonite group and of kaolinite, Ulrich Hofman in cooperation with Armin Weiss, G. Koch, A. Mehler, and A. Scholz

Thermodynamic, quasithermodynamic, and non-thermodynamic methods as applied to the electrochemistry of clays, C. Edmund Marshall

Kinetic studies on montmorillonites and nontronite by the acid-dissolution technique, Bernard Osthaus

Degradation of hectorite by hydrogen ion, G. T. Kerr, R. H. Zimmerman, H. A. Fox, Jr., and F. H. Wells

X-ray studies of the alteration of soda feldspar, G. W. Brindley and E. W. Radoslovich

The influence of ionic substitution on the hydrothermal stability of montmorillonoids, F. A. Mumpton and Rustum Roy

Effect of weathering on clay minerals, Haydn H. Murray and R. K. Leininger

Altered wall rocks along vein deposits in the Central City—Idaho Springs region, Colorado, E. W. Tooker

Mineral content and distribution as indexes of weathering in the Omega and Ahmeek soils of Northern Wisconsin, L. D. Whittig and M. L. Jackson

Clay minerals research at Ghent University, W. Dekeyser

Regularly interstratified montmorillonite-chlorite in basalt, J. W. Early and I. H. Milne

The distribution and identification of mixed-layer clays in sedimentary rocks, Charles E. Weaver

Mixed-layered structures in vanadium clays, John C. Hathaway

Types of mixed-layer minerals from Japan, Toshio Sudo and Hisato Hayashi

Weathering of mixed-layer clays in soils, Tsuneo Tamura

Interstratification of layer silicates in two soil clays, W. R. Schmehl and M. L. Jackson

Vermiculite as a member in mixed-layer minerals, H. Heystek

A study of the contents of these papers shows that approximately one-third of them are concerned with the characterization of the clay mineralogy, another third with the physical chemistry of clays and clay suspensions, and the remaining third with the progress of clay mineral research in six countries outside the United States.

This book is indispensable to those interested in clays from the standpoint of mineralogy, of geology, or of their behavior in various physical and chemical environments. It sets forth the latest techniques of investigation and interpretation. Anyone who works with clays will want to consult this book.

George T. Faust

EARLE R. CALEY and JOHN F. C. RICHARDS, *Theophrastus on Stones*, Ohio State Univ. Press, Columbus, Ohio. vii + 238 pp., 1956, \$6.00.

Theophrastus, book *On Stones* is a basic reference work on early Greek studies on minerals and rocks and on the materials derived from them. Theophrastus classified mineral substances into two categories—stones and earths. Earths were considered to contain pores large enough in size to admit water and thus undergo disintegration. Stones were considered to be compacted earths. Heating earth, that contained water in its pores until it solidified produced 'stone.' These concepts were apparently based on Aristotle's philosophic views.

Ancient localities for stones, such as the marbles from the Island of Paros and from Mt. Pentelicos near Athens are discussed. Chemical processes, such as the 'burning' of marble to make quicklime, are described. *On Stones* is a summary of early Greek practical mineralogy.

The book contains: bibliographic data on the early sources and translations; a copy of the Greek text; the *Apparatus Criticus* (materials for critical study of the manuscript); the translation; the commentary and the works of reference. There is an index to the Greek text, to the translation, and to the commentary.

The publication of this book makes available to modern-day students of the Earth sciences an authoritative treatment of an early classical work at a modest price. The reader who starts this book will find it hard to lay aside. It is strongly recommended for those interested in the early development of the Earth sciences.

George T. Faust

E. J. GUMBEL, *Statistics of Extremes*, Columbia Univ. Press, 347 pp., 1958, \$15.00.

Probably the one factor that has done more than any other to retard the use of probability theories by the engineering profession has been the feeling of uncertainty created by the conflicting opinions among mathematicians and statisticians regarding the application of these theories to the occurrence of natural phenomena. This conflict has centered largely in attempts to assign frequency distributions to infinite populations based on small samples drawn from those populations. The fact that engineers have been interested primarily in extremes has complicated this problem in that it has been necessary to consider, not only the initial distribution of which the extremes were a part, but also the distribution of the extremes themselves.

In his book, Gumbel has brought together under one cover and in logical sequence the many stages of development of the theory of extreme values, much of which is his own original contribution. His long association with the engineering profession has led to a sympathetic understanding of the engineer's problems and has given a practical slant to what might otherwise have been a mathematical statistician's rigid treatment of a complex subject.

The first chapter deals with definitions of terms and a discussion of the statistics to be used. The second and third chapters are concerned with distribution-free characteristics and the general properties of extremes without regard to initial distributions. The fourth chapter considers the exact distribution of extremes for two types of unlimited initial distributions and for a third type consisting of a number of limited distributions. Chapters 5, 6, and 7 are devoted to a study of three asymptotic theories and their application to the initial distributions considered in chapter 4. Practical applications of these theories to engineering problems are discussed. The eighth and final chapter discusses various statistics that may be determined for extremes and includes examples of their practical application in meteorological and engineering problems.

Although the book cannot be classed as easy reading and should not be attempted by those who have not had at least an elementary course in mathematical statistics, it is probably the most complete treatise on extreme values that has yet been written. Since it is replete with exercises, problems, and references, it is well suited for use as a textbook, and for hydrologists and engineers, it should provide an invaluable reference.

W. D. Potter

Contents of Bulletin (Izvestiya), Academy of Sciences, U.S.S.R. Geophysics Series, January-September, 1957

Note—Later issues of the *Transactions* will include titles from succeeding numbers of this publication. The production of the English edition of *Izvestiya* for 1957 was undertaken on behalf of the American Geophysical Union by Pergamon Press, with the aid of a grant from the National Science Foundation. Orders for sets (\$25.00 plus a service charge of \$3.00) should be sent to the American Geophysical Union.

The production of the twelve numbers issued in 1958 is being undertaken directly by the American Geophysical Union. Subscriptions for the volume, numbers sent as issued, are \$25.00.

No. 1, January 1957

TERRESTRIAL PHYSICS

- Seismology in the Chinese People's Republic, E. A. Koridalin, 8 pp.
Some problems of the investigation of the seismic activity of the Ashkhabad region, D. N. Rustanovich, 13 pp.
A study of the Plutonic structure of the Earth's crust using *PS* exchange waves recorded during earthquakes, S. S. Andreev, 10 pp.
Calculating the influence of topographical masses on underground gravitational measurements, V. A. Kazinskii, 11 pp.
Frequency investigations in detailed electrical prospecting, A. G. Ivanov, 14 pp.
Magnetic stability of rocks, G. N. Petrova, 11 pp.
Experimental research into the natural electromagnetic field of the Earth in the frequency spectrum of 2-300 c/s, B. S. Enenshtein and L. E. Aronov, 11 pp.
Large-scale turbulence and structure of the riverbed process, M. A. Velikanov, 8 pp.

ATMOSPHERIC PHYSICS

- Theoretical model of a waterspout, L. N. Gutman, 17 pp.
Compensation downdrafts caused by growing cumulus clouds, N. I. Vul'fon, 16 pp.
A photoelectric method of investigating the distribution of particle size of precipitation, A. E. Mikirov, 6 pp.

REPORTS AND NOTES

- Gamma-gamma core-sampling by electrical means in Ural coal deposits and the possibility of core-free boring of part of the prospecting holes, Iu. P. Bulashevich and G. M. Voskoboinikov, 5 pp.
Electrodynamic seismograph for recording large displacements, D. A. Kharin and B. G. Rulev, 4 pp.
A cylinder in the field of a point source of electric current, B. P. D'Iakovon, 6 pp.

- On the effect of the Perseid meteoric stream on the electric field of the Earth's atmosphere, M. V. Okhotsimskaya, 2 pp.
On the determination of the velocity of corpuscles, projected from active regions of the Sun, from the time-lag before their appearance on Earth, V. A. Petukhov, 1 p.

CURRENT EVENTS

- Session of Seismology Council, N. V. Kondorskaya, 5 pp.

No. 2, February 1957

TERRESTRIAL PHYSICS

- On the study of the structure of the Earth's crust during the third International Geophysical Year, Iu. V. Rizinchenko, 14 pp.
Tectonophysical foundation of geological seismicity criteria—I, M. V. Gzovskii, 21 pp.
On the theory of scattering of elastic waves from a curvilinear boundary, G. A. Skuridin, 23 pp.
Features of a device for seismic depth sounding and results of its testing, G. I. Aksenovich, E. I. Gal'perin, and M. A. Zaiionchkovskii, 10 pp.
Investigation of breakdowns during the torsion of thin specimens of rocks under unilateral pressure, M. P. Volarovich and E. I. Parkomenko, 11 pp.
On the choice of the optimum frequency in the induction method of electrical prospecting, F. M. Kamenetskii, A. A. Kaufman, and Iu. V. Iakubovskii, 11 pp.
Approximate formula for a calculation of the variable magnetic field over a lode, A. G. Ivanov, 7 pp.
Laboratory studies of induced polarization in sedimentary rocks, I. I. Rokitsanskii, 13 pp.

ATMOSPHERIC PHYSICS

- Determination by hydrodynamic methods of the annual course of air temperature at sea level, G. P. Kiorbatkin, 17 pp.
Specific features in evolution of the fields of temperature humidity and pressure in developing cyclones, Kh. P. Pogossian and A. I. Burtsey, 12 pp.

REPORTS AND NOTES

- Seismic activity in the U.S.S.R. in 1955, N. V. Kondorskaya and G. A. Postolenko, 4 pp.
Climatological evaluation of the results of microclimatic observations, Iu. L. Rauner, 8 pp.
Relationship between the light-scattering coefficient for a ray and the attenuation factor for terminally diffused light in turbid media, V. A. Timofeeva, 8 pp.

No. 3, March 1967

TERRESTRIAL PHYSICS

- Tectonophysical foundation for geological criteria of seismicity—II, M. V. Gzovskii, 12 pp.
- The dynamic characteristic of earthquakes in the Caucasus, O. D. Gotsadse, 17 pp.
- Study of alternating refracted waves in seismic prospecting, Yu. I. Vasil'ev, 26 pp.
- Investigation of elastic wave velocities in rock-samples under a pressure of up to 5000 kg/cm², M. P. Volarovich and D. B. Balashov, 14 pp.
- An optical system for photo-recording oscillation processes, E. S. Borisevich, 12 pp.
- The determination of the acceleration due to gravity at sea by a pendulum method, V. A. Roman-yuk, 12 pp.
- The theoretical basis of selective gamma-gamma core sampling, G. M. Voskoboinikov, 14 pp.
- Investigation of the susceptibility and saturation magnetization of sedimentary rocks in weak magnetic fields, R. S. Taichinov, 7 pp.

MARINE PHYSICS

- An investigation of free oscillations of daily and twice-daily types for a liquid in shallow seas—II, F. S. Ratser-Ivanova, 17 pp.

ATMOSPHERIC PHYSICS

- The application of the method of spherical harmonics to the problem of the scattering of light in the atmosphere, S. Ya. Kogan, 13 pp.
- Atmospheric turbulence, commensurate with dimensions of airplanes, N. Z. Pinus, 7 pp.

REPORTS AND NOTES

- Rock resistivities by a.c. methods, B. S. Enenashstein, 4 pp.
- On the connection between change of amplitude and phase of an electric field, and the elements of an elliptical magnetic polarization, O. M. Barsukov, 4 pp.
- The stability of surface waves in streams moving at an angle to each other, L. S. Gandin, 4 pp.

RECENT EVENTS

- Conference of junior scientific workers, engineers, and postgraduate students of the Institute of Geophysics of the Academy of Sciences of the U.S.S.R., F. A. Kirillov, 8 pp.
- All-Union interdepartmental conference on aerial surveying, M. M. Belokopytov, V. M. Devitsin, and M. I. Lapina, 3 pp.

No. 4, April 1967

TERRESTRIAL PHYSICS

- Investigation of dynamic moduli of elasticity for rocks in relation to temperature, M. P. Volarovich and A. S. Gurvich, 9 pp.
- On the methodology of calculating the dynamic characteristics of seismic waves, I. N. Malinovskaya, 16 pp.

- The theory of waves due to displacements, V. I. Keilis-Borok, 10 pp.
- Wave form changes on reflection and refraction, B. S. Chekin, 11 pp.
- Determination of the force of gravity at sea by the pendulum method—II, V. A. Romanyuk, 15 pp.
- Electrical prospecting for pyrite deposits under an absorbing surface layer, I. K. Ovchinnikov, 11 pp.
- High-frequency frame galvanometers, E. S. Borisevich, 18 pp.

MARINE PHYSICS

- On the propagation of a tidal wave in a strait, T. Ia. Sekerzh-Zenkovich, 12 pp.

ATMOSPHERIC PHYSICS

- The effective recombination coefficient in the ionosphere, V. I. Krasovskii, 8 pp.
- Measurement of particle-size distribution in clouds and fogs, A. E. Mikirov, 5 pp.

REPORTS AND NOTES

- A static method for determining the piezoelectric moduli of rocks, E. I. Parkhomenko, 5 pp.
- The balancing of an elastic structure of gravitation variometers, V. A. Kazinskii, 3 pp.
- Another criterion for testing the interpretation of gravitation anomalies, E. G. Bulakh, 2 pp.
- Calibration of amplitude-phase electro-geophysical apparatus, O. M. Barsukov, 3 pp.
- Telluric current storm during 6 to 8 October 1949, A. G. Ivanov and R. I. Khovanova, 3 pp.
- Temperature conditions in an artificial Earth satellite, A. G. Karpenko and M. L. Lidov, 10 pp.
- Some icing problems in propeller aircraft, I. P. Mazin, 7 pp.
- Data on the infra-red spectral energy distribution of the aurora, B. A. Bagariatskii, 4 pp.
- Radio reflections from aurorae, Ya. G. Birfel'd, 6 pp.
- The temperature and humidity of the air over a drained marsh, I. D. Kopanev, 4 pp.
- An experiment on the direct measurement of the variation in atmospheric humidity with height by a spectral method, B. S. Neporent, V. F. Belov, O. D. Dmitrievskii, G. A. Zaitsev, V. G. Kastrov, M. S. Kiseleva, L. A. Kudriavtseva, and I. V. Patalakhin, 5 pp.
- On the modelling of the terminal velocity of particles in a medium, E. A. Novikov, 2 pp.

RECENT EVENTS

- The First Seismological Conference of the Czechoslovak Academy of Sciences, 2 pp.

No. 5, May 1967

TERRESTRIAL PHYSICS

- Tracing buried dislocation zones by means of dynamic characteristics of refracted waves, S. P. Starodubrovskaya, 21 pp.
- On the dynamic characteristics of longitudinal re-

- lected waves beyond the critical angle, L. N. Malinovskaya, 8 pp.
- Dynamic characteristics of reflected waves whose arrival times are not true minima, S. A. Fedotov, 12 pp.
- Application of linear systems to the filtration of compound oscillations, F. M. Gol'tsman, 11 pp.
- The stability of normal rock magnetization, A. S. Bol'shakov, 10 pp.
- Convection in the Earth's envelope according to the calculations of Pekeris, E. N. Lyustikh, 13 pp.

MARINE PHYSICS

- Determination of the stationary wind-created currents and the incline of the level in the uniform ocean, A. S. Sarkisian, 12 pp.

ATMOSPHERIC PHYSICS

- Calculation of the non-uniformity of the underlying surface in problems on the scattering of light in the atmosphere, M. S. Malkevich, 18 pp.
- Direct radiation and the transparency of the atmosphere, L. G. Marhotkin, 14 pp.
- The water balance of a cloud system, E. F. Mamina and E. K. Fedorov, 7 pp.
- The nature of the changes of intensity of the radiation of the Earth's atmosphere, V. I. Krasovskii, 6 pp.

REPORTS AND NOTES

- On reducing the dimensions of the quartz components in the Norgard and SN-3 gravimeters, E. I. Popov, 3 pp.
- The role of radiative heat transfer in the hot regions of the Earth, E. A. Lyubimova, 5 pp.
- A converse problem of electrical prospecting theory, D. N. Chetaev, 3 pp.
- Calculation of the magnetization of prisms for constant susceptibility, E. N. Mokhova, 4 pp.
- Angular dispersion on the intensity of thermal radiation in the atmosphere, M. P. Elovskikh and K. Ya. Kondrat'ev, 7 pp.
- The separate study of the particle distribution spectrum in liquid and solid aerosol fractions, A. E. Mikirov, 4 pp.
- Electrophoretic measurements of the aurorae, N. V. Dzhordzhio, 5 pp.

No. 6, June 1967

TERRESTRIAL PHYSICS

- On the nature of certain waves obscuring detection of reflected waves on the Russian Plateau, I. S. Berson and I. I. Ratnikova, 15 pp.
- Reflected waves produced at angles of incidence greater than critical, A. M. Epinat'eva, 25 pp.
- Some special characteristics of thermal magnetization, G. N. Petrova and G. A. Pospelova, 11 pp.
- The possibility of establishing the original remanent magnetization of rocks, A. S. Bol'shakov, 8 pp.
- Acoustical observations in shafts of the Kizelsk coal basin, S.-D. Vinogradov, 13 pp.

MARINE PHYSICS

- Experimental investigation of horizontal turbulent diffusion in the sea and in a shallow artificial reservoir, R. V. Ozmidov, 11 pp.

ATMOSPHERIC PHYSICS

- Some results of an investigation of turbulent pulsations of temperature and the vertical component of wind speed, A. V. Perepelkina, 16 pp.
- The influence of thermophoresis on the coagulation of droplets in clouds, B. V. Deriagin and S. S. Dukhin, 7 pp.

REPORTS AND NOTES

- Seismic activity and the work done by the Caucasian seismic stations in 1954-55, A. D. Takhakaya, 6 pp.
- The distribution of radon in porous deposits in the presence of radium-scattering aureoles, A. G. Grammakov and I. F. Popretinskii, 7 pp.
- The analytical interpretation of data in electrical exploration by the natural field method under conditions of complicated topography, D. N. Chetaev, 9 pp.
- Nature of terrestrial electric currents and their study at the ocean bed, B. P. D'yakonov, 5 pp.
- The geological interpretation of gravitational anomalies in mining ore deposits, V. A. Kazinskii, 7 pp.
- Study of the possibility of lowering the temperature coefficients of quartz gravimeters by changing over to glass with a low thermo-elastic coefficient, E. I. Popov, 6 pp.
- The characteristics of the real properties of paleozoic rocks in Tartary, A. I. Krinari and V. L. Zuekov, 7 pp.
- One possible cause of major magnetic anomalies, V. I. Pochtarev, 6 pp.
- Numerical methods for forecasting a baric field in the atmosphere, A. S. Chaplygina, 6 pp.
- Forecast of natural photometric intensity, K. S. Shifrin and L. N. Guseva, 7 pp.
- The influence of stratification on thermal radiation in the atmosphere, K. Ya. Kondrat'ev and T. K. Yastrebova, 4 pp.
- The dissemination of dust and gases from factory chimneys, A. I. Denisov, 5 pp.
- The distribution function of liquid particles in rainfall, I. V. Litvinov, 3 pp.

No. 7, July 1967

TERRESTRIAL PHYSICS

- Approximate calculation of reflected and refracted waves, A. F. Filippov, 16 pp.
- Elastic waves in a laminated solid medium, as investigated on two-dimensional models, Yu. V. Rimichenko and O. G. Shamina, 21 pp.
- An experimental application of the seismic depth-sounding method to the investigation of the structure of the Earth's crust in parts of Western Turkmenia, I. P. Kosminskaya and Yu. V. Tulina, 20 pp.
- Regional peculiarities in the travel times of seismic waves, N. V. Kondorskaya, 20 pp.

ATMOSPHERIC PHYSICS

The intake of aerosol samples, L. M. Levin, 15 pp.

REPORTS AND NOTES

- Determining the intensity of an earthquake from the surface wave soil displacement, S. L. Solov'yov and N. V. Shebalin, 7 pp.
- The use of short-period seismographs for isolating exchanged waves on traces of distant earthquakes, S. S. Andreev and N. V. Shebalin, 4 pp.
- Low-frequency electromagnetic investigation of the surroundings of boreholes, V. I. Veksler and M. I. Plyusmin, 8 pp.
- On the use of the magnetic susceptibility of rocks for purposes of correlation, R. S. Taichinov, 5 pp.
- Some instances of thermomagnetization of ferromagnetic bodies, G. K. Kuzhelov, 7 pp.
- On the determination of small quantities of radon and thoron in their mixture, Z. L. Sinityn, 6 pp.
- Towards the hydrodynamic theory of centers of action of the atmosphere, A. S. Chekirda, 6 pp.

CURRENT EVENTS

- A Conference on Tectonic Physics, 11 pp.
- The tasks and activities of the consultative committee attached to the Presidium of the Academy of Sciences, USSR., for preparing and implementing the International Geophysical Year, 5 pp.

No. 8, August 1957

TERRESTRIAL PHYSICS

- The seismic character of the Kola peninsula and North Kareliya, G. D. Panasenkov, 10 pp.
- On electric geophysical exploration methods of a pure anomaly, A. G. Tarkhov, 12 pp.
- The Gegechkori earthquakes of January 1957, A. D. Tshakaya, 11 pp.
- Measuring magnetic properties of rocks with an astatic magnetometer, S. P. Burlataya, 9 pp.

MARINE PHYSICS

- Non-stationary wind driven currents in a homogeneous ocean, A. S. Sarkisyan, 13 pp.

ATMOSPHERIC PHYSICS

- The form of smoke jets, A. B. Kazanskii and A. S. Monin, 15 pp.
- The sedimentation of aerosol particles from a stream on to an obstacle, E. A. Novikov, 12 pp.
- The influence of the hydrodynamic interaction of small cloud droplets on their fall velocity, S. V. Pshenai-Severin, 8 pp.

REPORTS AND NOTES

- Some features of the field of displacement of longitudinal and transverse waves propagated in the Earth's shell, A. V. Vvedenskaya and L. M. Balakina, 4 pp.
- Application of layer velocities for construction of

- geological sections, F. M. Lyakhovitskii, 7 pp.
- The first results of working with the azimuthal setting of inclined receivers, V. F. Bonchovskii and R. M. Karmaleeva, 6 pp.
- Direct-vision magnetograph, B. E. Brunelli and D. A. Nizyaev, 7 pp.
- The nature of the gravitational and magnetic anomalies of the central and eastern regions of the Russian platform, N. V. Nevolin, 5 pp.
- Study of the motion of suspended drift by the photo-electric method under laboratory conditions, M. V. Lomonosov, V. P. Petrov, and Z. N. Kotova, 7 pp.
- Book Review (No. 1 of *Trudy* of the Geological Institute of the Ukrainian Academy of Sciences, Geophysics Series No. 1, bearing on seismology, Kiev, 1956), 3 pp.

TOPIC OF INTEREST

- The 1667 earthquake in Daghestan, L. Lavrov, 1 p.
- No. 9, September 1957*

TERRESTRIAL PHYSICS

- Grouping of the first kind and a method for obtaining multi-component azimuthal seismograms, E. I. Gal'perin, 23 pp.
- Frequency analyzer for seismic vibrations, L. L. Khudzinskii and A. Ya. Melamud, 22 pp.

MARINE PHYSICS

- The coefficient of vertical turbulent exchanges in the sea, S. A. Kitaigorodskii, 17 pp.

ATMOSPHERIC PHYSICS

- The accuracy of computation of advective variations of fields in quantitative forecasting of weather, A. M. Obukhov, 10 pp.
- Assessing the influence of mountains in pressure field forecasting, S. L. Belousov and V. V. Bykov, 18 pp.
- Observations of the vertical distribution of ozone in the atmosphere, A. P. Kuznetsov, 10 pp.
- Application of the microphotometer to the numerical analysis of atmospheric dust, K. P. Makhon'ko, 11 pp.

REPORTS AND NOTES

- Certain criteria for checking the interpretation of gravitational and magnetic anomalies, E. G. Bulakh, 6 pp.
- Depth determination of beds of disturbing masses from local narrow anomalies, L. Ya. Provodnikov, 5 pp.
- Effect of fiber torsion on the readings of pendulum clinometers, V. F. Bonchovskii and R. M. Karmaleeva, 4 pp.
- Certain results of electrical prospecting over a broken relief, N. P. Vladimirov, 4 pp.
- Determination of ray intensity in volume radioactive sources allowing for the effect of scattering, A. A. Korzhnev, 6 pp.
- Light conditions in the rivers Rion, Kuban, and Don, L. A. Hukina, 8 pp.

Notes and Personalia

Notes

NEW OCEANOGRAPHIC VESSEL OF THE NAVY—The Navy's newest and largest oceanographic vessel, the *Gibbs*, was placed in operation by the Navy in December 1958. It will serve as the principal research vessel of Hudson Laboratories of Columbia University under contract with the Office of Naval Research. It is the altered seaplane tender *San Carlos*, has a displacement of 2800 tons, is 310 feet long, and is capable of a maximum speed of 18 knots. It will have a crew of 48 and provide facilities for 28 scientists, and will be used especially to study the physics of the ocean itself and of sound in the ocean. The *Gibbs* is the second oceanographic research vessel placed in operation late in 1958, the first being the *Chain* which is on contract with the Woods Hole Oceanographic Institution. The *Chain* is 210 feet long, has a displacement of 1800 tons, and is capable of a maximum speed of 14 knots.

INTERNATIONAL OCEANOGRAPHIC CONGRESS—This Congress, under the sponsorship of UNESCO, the International Council of Scientific Unions, and the American Association for the Advancement of Science, will be held at the United Nations in New York, August 30 to September 12, 1959. Mary Sears of the Woods Hole Oceanographic Institution is General Chairman of the Committee on Arrangements.

WORLDWIDE STUDY OF CHEMICAL DENUDATION OF LAND—Streamflow data and two-liter samples of water from 65 major rivers throughout the world are being processed by the U. S. Geological Survey as part of a worldwide effort to determine how much water flows into the oceans and how much these rivers carry as dissolved solids. The work is part of a plan developed by the Association of Hydrology of the IUGG to gather data on the broader aspects of these problems. Water samples will be taken at least four times a year near the mouth of each river far enough from the sea to avoid contamination by sea water. One set is to be collected at high flow, one at low flow, and one set each slightly above and slightly below the median flow. The 65 rivers chosen are believed to provide up to 75 pct of the total runoff to the oceans.

FUNDS FOR NATIONAL ASTRONOMICAL OBSERVATORY—The National Science Foundation announces that \$4 million additional has been allocated to the Association of Universities for Research in Astronomy, Inc. (AURA), bringing the total to \$7,545,000. The observatory is to be located on Kitt Peak in the Quinlan Mountains of southwestern Arizona. Both solar and stellar telescopes are to be installed. Construction operations are awaiting final action on the lease of the lands from the Papago Indians, legislation permitting such a lease having been approved by Congress in 1958. The following universities are connected with AURA: California, Chicago, Harvard, Indiana, Michigan, Ohio State,

Wisconsin, and Yale. As the project develops it is expected that other universities will be added.

NEW SERIES OF BULLETINS ON SCIENTIFIC ACTIVITIES IN FEDERAL AGENCIES—The first of these bulletins relating to the Department of Agriculture has been published by the National Science Foundation. It outlines the research activities of the Agricultural Research Service, the Forest Service, the Agricultural Marketing Service, and the Farmer Cooperative Service. Requests for single copies of the first bulletin should be addressed to FCS Information Division, U. S. Department of Agriculture, Washington 25, D. C.

EARTHQUAKE FREQUENCY AND INTENSITY MAPS—The California Institute of Technology has recently released maps relating to the earthquakes, these being the result of extensive studies by Charles F. Richter, basing the information on local geology, proximity to active faults, and the history of earthquakes in the area. These should prove of great use in building design and in long-range planning. Zones of high earthquake intensity and frequency may lie quite close to areas of low intensity and frequency. The release notes that while California produces 80 to 90 pct of the earthquakes in the United States, there are also other high risk areas and California includes some of the lowest risk areas in the map.

PROGRAM OF SUMMER INSTITUTES FOR HIGH SCHOOL AND COLLEGE TEACHERS IN SCIENCE AND MATHEMATICS—The program instituted in previous years by the National Science Foundation to offer courses to high school and college teachers of science and mathematics will benefit some 18,000 teachers at the 350 Summer Institutes to be held during the summer of 1959. Grants totaling approximately \$21,000,000 in support of the institutes were recently announced. They will be held in all of the 49 states; also in Hawaii, Puerto Rico, and the District of Columbia. Some 300 of the institutes will be open only to high school teachers and approximately 30 only for college teachers. Tuition and fees of the teachers, plus a stipend to aid in living expenses, are granted. The participants are chosen by the institutes themselves, not by the National Science Foundation. A list of the institutions where the institutes will be held may be secured by writing to the National Science Foundation, Washington 25, D. C.

CLOSURE OF LARGE DAM ON THE ZAMBESI RIVER IN AFRICA—The Kariba Dam that crosses the Zambesi River in Southwest Africa between Southern and Northern Rhodesia has now been closed, beginning the impounding of the waters of the reservoir which will take from three to six years to fill while the work of completion of the Dam is under way. The Dam is about 420 feet high and 80 feet thick, and will create a lake which will have a capacity of 140 million acre feet of water,

the largest man-made reservoir in the world. In addition to the use of water for irrigation and other purposes, it is anticipated that this project will have a total capacity of not less than 1,500,000 kilowatts.

During the early stages of the construction of the Dam in February 1958 the greatest floods in the history of the River occurred, doing much damage to bridges, construction roads, and offices, and to some equipment. The work was stopped for some time while the flood subsided and equipment was replaced. The Dam is located in the Kariba Gorge some 180 miles northwest of Salisbury. About 50,000 Tonga tribesmen who live in the valley above the Gorge have had to be resettled.

GLACIER STUDIES BY GEOCHEMICAL METHODS—The Geochemical Laboratory of the California Institute of Technology is undertaking studies of hundreds of samples of melted ice from the Antarctic, from Greenland, and from the glaciers of North America through mass spectrometer measurements in an effort to disclose details of the history of weather in the areas involved for the hundreds of years represented by the samples. Isotopes of oxygen are believed to be the key to many of the questions.

NEW GEOPHYSICS COURSE AT LEHIGH UNIVERSITY—Lehigh University has added a course on magnetic and gravitational prospecting to its curriculum in mining engineering.

COMMITTEE NAMED TO STUDY THE SCIENTIFIC AGENCIES OF THE DEPARTMENT OF COMMERCE—The National Academy of Sciences has appointed a special committee of scientists and research administrators to study the scientific programs of the Department of Commerce. Mervin J. Kelly, President of Bell Telephone Laboratories, is Chairman of the Committee. Others include Horace R. Byers, Abel Wolman, and Michael Ference, Jr. John C. Green, Director of the Office of Technical Services of the Department of Commerce, has been named Executive Secretary of the Committee.

NEW WEATHER FORECASTING SERVICE—The U. S. Weather Bureau has announced that new forecasting services will begin early in 1959 for jet flights from major airports, giving information on flight levels between 20,000 and 45,000 ft.

VISITING LECTURER PROGRAM IN METEOROLOGY—The American Meteorological Society is sponsoring a visiting lecturer program dealing with meteorology and the atmospheric sciences with the aid of a grant from the National Science Foundation. The purpose is to arrange for visits to colleges and universities of research meteorologists to give lectures and to hold informal discussions with faculty and students. Address all correspondence to Henry G. Houghton, American Meteorological Society, 3 Joy Street, Boston 8, Mass.

NEW SPECIES DRAGGED FROM THE DEPTHS OF THE PACIFIC—Ancestors of the snail (paleozoic neopilina) believed to have been extinct for 300 million years have been dragged up alive from three-mile depths in the Pacific Ocean. The tiny creatures, cone-like in shape about $1\frac{1}{2}$ inches long, have

changed little since their history began some 500 million years ago. Four were brought up alive in nets by the *Vema* of the Lamont Geological Observatory. They are believed to be one of the two oldest forms of animal life, the other being the lingula, a shell-bearing animal found in the shallow waters near Japan.

UNESCO RESEARCH SHIP—Plans are under study to determine whether UNESCO should sponsor an international research ship to supplement the research already being carried out on an international basis by many countries but which could undertake oceanographic problems that cannot be undertaken by existing ships. This idea was put forth by a group of international marine scientists who had a meeting in the autumn in Paris. It was suggested that the ship should be one of about 1200 tons, about 220 ft long, providing laboratory space for six permanent scientists, fifteen visiting scientists, and students in training. An alternative proposal was made that UNESCO should operate a number of chartered research ships on an international basis. The proposals are now before the Director-General of UNESCO.

NEW DEVICE FOR CALIBRATING AIRBORNE COMPASSES—The Air Research and Development Command and the Sperry Gyroscope Company have announced a new technique for calibrating airborne compasses by 'rotating the world' around a stationary aircraft or guided missile. The equipment rotates the Earth's magnetic field electronically and eliminates the time-consuming checks that have hitherto been necessary.

PROJECT VANGUARD TRANSFERRED FROM NAVAL RESEARCH LABORATORY TO NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—This transfer was made effective October 1, 1958, and gave the staff members of Vanguard the option of transferring to the new agency or remaining with NRL. Most of them have elected to stay with the project, and because of the fact that NASA is in operation administratively but has no laboratory quarters, they will continue their activities in the facilities hitherto used by Vanguard.

SYMPOSIUM ON THE PHYSICS OF ICE MOVEMENT—The Association of Hydrology of the International Union of Geodesy and Geophysics held a Symposium on the Physics of Ice Movement at Chamonix, France, September 16-24, 1958, this having been arranged by the Commission for Snow and Ice of the Association. Nearly 100 persons were in attendance, and 15 countries were represented. The arrangements for the symposium were made by L. J. Tison, Secretary of the Association. The 41 papers presented are available and may be secured by ordering these direct from Prof. L. J. Tison, 61, Rue des Ronces, Gentbrugge, Belgium.

FORMATION OF A NEW SCIENCE INFORMATION COUNCIL—The National Science Foundation has announced the appointment of a 19-member Science Information Council in accordance with the provisions of legislation passed in 1958. As the Council includes scientists, specialists in scientific documentation, and representatives of the lay

public, it would be in a position to provide the newly formed Science Information Service of the NSF with a broad range of technical skills and experience on problems in the dissemination of scientific information and communication. One member of AGU is included in the membership of the Council: John W. Mauchly, Director of UNIVAC Applications Research Center in Philadelphia.

NEW SCIENCE INFORMATION SERVICE OF THE NATIONAL SCIENCE FOUNDATION—In accordance with the National Defense Education Act of 1958 and as directed by President Eisenhower on recommendation of his Science Advisory Committee, the National Science Foundation has established a Science Information Service designed to make scientific literature in all languages more readily available to scientists and engineers. The new service is headed by Burton W. Adkinson.

VISIT OF RUSSIAN IGY VESSEL—The motorship *Vityas* of the Institute of Oceanology of the U.S.S.R. Academy of Sciences arrived at San Francisco on December 17, 1958 for a five-day visit. Members of the scientific party visited the Scripps Institution of Oceanography at La Jolla, the Pacific Marine Station at Dillon Beach, the California Academy of Sciences, Stanford University, and the University of California. A scientific symposium summarizing results obtained by the *Vityas* during the present cruise, which is the fourth voyage undertaken by the vessel in the Pacific as part of the IGY program, was held on board the vessel. The last previous port of call of the *Vityas* was Vancouver, B. C., and she is scheduled to touch also at Honolulu during the present voyage. N. N. Sysoyev, Deputy Director of the Institute of Oceanology, is scientific leader of the expedition.

CONTINUED AID TO EDUCATION OF THE SHELL COMPANIES FOUNDATION—During 1959 the Shell Companies Foundation will contribute almost \$700,000 to the support of education, including summer seminars for high school science and mathematics teachers, graduate fellowships, grants and assistance to a number of colleges and universities, and support of national associations in the field of education.

ARTIFICIAL AURORA—The Apia Observatory at latitude 13°S and longitude 171°W recently reported a brief auroral display at the time of a nuclear explosion 100 miles above Johnston Island at 17°N and 169°W, a distance of some 2200 miles which is too great for direct visual observation at a point in the upper atmosphere of Apia. In a letter in *Nature* (vol. 182, Dec. 20, 1958, p. 1728), P. H. Fowler and C. J. Waddington of the Wills Physical Laboratory of the University of Bristol explained that direct radiation could hardly cause the observed aurora, but that, on the other hand, if a nuclear explosion is produced high enough in the atmosphere, charged particles emitted as a result could be guided along the lines of force of the Earth's magnetic field and returned to Earth at a point on the same geomagnetic longitude and

opposite geomagnetic latitude. The situations of these two stations are such as to provide this circumstance with respect to the geomagnetic equator.

CENTRAL AGENCY FOR CARBON-14 DETERMINATION OF SEA WATER—In January 1958, UNESCO provided funds for the establishment at the Danish Institute for Fisheries and Marine Research of an international radiochemical laboratory, facilities for which would be available to smaller marine laboratories for the study of primary production in the sea using the methods of carbon-14. Full details can be obtained by writing to the International Agency for Carbon-14 Determination, Charlottenlund Slot, Charlottenlund, Denmark, Attention of Prof. E. Steemann Nielsen.

CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT—What is noted as the first International Conference on Waste Disposal in the Marine Environment will be held at the University of California in Berkeley some time during the summer of 1959. Specific dates are not yet set. Problems of waste disposal, public health, nearshore oceanography, analysis of receiving water, marine biota, and estuarine hydrography are on the agenda. Details may be secured by writing to the Department of Conference, University Extension, University of California, Berkeley 4, California.

PERSPECTIVES ON CONSERVATION—A collection of papers by some 23 authorities has been compiled in a book under this title by Resources for the Future and published by Johns Hopkins Press in Baltimore at a price of \$5.00. The essays are grouped under six headings as follows: (1) The first fifty years; (2) Science, technology, and natural resources; (3) Resource demands and living standards; (4) Urban growth and natural resources; (5) Some determinants of resource policy; and (6) Organizing for conservation and development.

WATER BALANCE MAPS OF EASTERN NORTH AMERICA—C. W. Thornthwaite, John R. Mather, and Douglas B. Carter of the Laboratory of Climatology have been collecting data that will assist in determining the water balance of areas throughout the world. Under sponsorship of Resources for the Future, Inc., they have recently compiled three five-color maps, 21 by 29 inches, which show the area extending from James Bay to the Gulf of Mexico. These maps show potential evapotranspiration, water surplus, and water deficit for this area, and are accompanied by a 56-page booklet interpreting the data. Maps and booklet may be obtained from Resources for the Future, Inc., 1145 Nineteenth Street, N.W., Washington 6, D. C. The price is \$2.00.

FOREIGN LANGUAGE KNOWLEDGE OF AMERICAN SCIENTISTS—The October 1958 issue of the *Scientific Manpower Bulletin* (no. 9) of the National Science Foundation notes that over 97,000 scientists in the National Register of Scientific and Technical Personnel report knowledge, with varying degrees of proficiency, of at least one foreign language. This constituted 75 pct of the 127,000

persons on the register at that time. However, only about 1 in 50 of those reporting indicated language ability in Russian and less than 1 in 100 in Chinese. The findings indicate that nearly all American scientists must depend upon translations for knowledge of the activities in science in those countries.

INFLUENCE OF WIND ON COASTAL WATERS—The National Science Foundation has recently made a grant of \$43,000 to the University of Florida to study the effects of high winds on coastal waters. The wave tank of the University of Florida as well as actual off-shore measurements will be involved. The study is under the direction of Per Bruun.

WORLD SURVEY OF SOLAR RADIATION—UNESCO, in cooperation with the World Meteorological Organization, is undertaking a worldwide survey of solar radiation during the next two years using at the same time data previously collected, including that of the International Geophysical Year. This is

all in connection with the effort to determine the most effective means and locations for plants to develop power from solar energy.

INDUSTRIAL EMPLOYMENT OF SCIENTISTS AND ENGINEERS—The National Science Foundation has found that American industry employed about two-thirds of the national total of scientists and engineers as of January 1957, the total number being 738,000 of whom 528,000 are engineers, 152,000 scientists, and 58,000 administrators of scientific and engineering activities. About one-third of those employed by industry are engaged in research and development. The full story is presented in a report entitled "Scientists and Engineers, in American Industry—January 1957," *Scientific Manpower Bul. 10*. Address the Public Information Office, National Science Foundation, Washington 25, D. C.

Personalia

WILLIAM MANSFIELD ADAMS, formerly with the Geotechnical Corporation in Dallas, Texas, has taken up duties at the Lawrence Radiation Laboratory in Livermore, California.

HARRISON BROWN, Professor of Geochemistry at the California Institute of Technology, was recently given the \$2500 Albert Laaker Award in Planned Parenthood for his synthesis of scientific data "into a comprehensive picture of the resources man needs to sustain himself" and for his great efforts to bring these findings before the public eye through lectures, papers, and other means, including two books entitled *The Challenge of Man's Future* and *The Next Hundred Years*.

FRED M. BULLARD, Professor of Geology at the University of Texas, has accepted a Fulbright Lectureship at the University of Arequipa, Peru, from February to September, 1959.

IAN CAMPBELL, Executive Officer of the Division of Geological Sciences in the California Institute of Technology, has been granted leave of absence to take up duties as Chief of the California Division of Mines.

ROBERT CHAPMAN, formerly with the Geophysics Research Directorate of the Air Force Cambridge Research Center, has taken up duties as Vice President and Director of Engineering of the newly formed Geophysics Corporation of America.

RICHARD D. COONS has taken up duties as Vice President and Director of Marketing with the newly formed Geophysics Corporation of America.

BERNARD FRANK, Assistant Director of the Division of Watershed Management Research of the U. S. Forest Service, has accepted a one-year assignment to India as an FAO specialist to develop a program of watershed management research with the Indian Forest Research Institutes. Studies will be undertaken in the mountain, semi-desert, and wet tropical forest regions in cooperation with State and Federal agencies concerned

with water control and soil conservation. His headquarters will be the Forest Research Institutes, Dehra Dun, U. P., India.

JAMES E. GALLAGHER, formerly with the Geophysics Research Directorate of the Air Force Cambridge Research Center, has taken up duties as Vice President and Director of Planning with the newly formed Geophysics Corporation of America.

BERTRAM C. GOODELL, Research Forester of the Rocky Mountain Forest and Range Experiment Station, has been assigned new duties in watershed management research giving special attention to fundamental studies of watershed vegetation and streamflow, cooperating with the new Watershed Management Unit of Colorado State University.

MILTON GREENBERG, former Director of the Geophysics Research Directorate of the Air Force Cambridge Research Center, has taken up duties as President of the newly formed Geophysics Corporation of America with headquarters in Boston. The group is concentrating initially on radiation physics, extraterrestrial radiation, physical and chemical properties of gases, and properties of magnetic and electrical fields.

MAHDI S. HANTUSH, until recently Dean of the College of Engineering of the University of Baghdad, is currently at the New Mexico Institute of Mining and Technology directing a ground-water research program.

VICTOR F. HESS of Fordham University, a Nobel prize winner for the discovery of cosmic rays, has been given the Insignis Medal of Fordham University for extraordinary distinction in the service of God through excellent performance in his profession.

HAROLD JEFFREYS of Cambridge University is undertaking duties as Distinguished Visiting Lecturer at the University of Minnesota during the spring quarter of 1959. He is presenting a series of

lectures on the subject "Elasticity and its Geophysical Applications."

MYRON G. H. LIGDA, formerly engaged in radar meteorology research at Texas A. and M. College, has taken up duties with Stanford Research Institute as Head of the Radar Aerophysics Group which will concentrate on improving techniques for detecting and locating storms and forecasting weather.

HAROLD M. MOONEY, Associate Professor of Geophysics at the University of Minnesota, is serving as Visiting Lecturer in the Institut für Geophysik, Eidg. Technische Hochschule, Zurich, Switzerland under a grant from the American-Swiss Foundation for Scientific Exchange.

HOMER E. NEWELL, JR. of Project Vanguard of the Naval Research Laboratory has taken up duties as Assistant Director of Space Sciences of the National Aeronautics and Space Administration.

JOHN A. O'KEEFE of the Army Map Service has taken up duties in the Theoretical Branch of the newly established National Aeronautics and Space Administration.

DONALD E. OUTLAW has left his work with the du Pont Company to establish an office as consulting hydrologist in Newark, Delaware. He is specializing in ground-water investigations, water supply, site surveys, watershed studies, and waste disposal, both atomic and industrial.

EMANUEL R. PIERE, Director of Research of the International Business Machines Corporation, has been named Chairman of the new Federal Council for Science and Technology which was recently established by executive order of the President to improve the planning and management of Government research programs and to facilitate the resolution of problems common to all Federal agencies engaged in scientific activities.

MARTIN J. POLLAK, formerly of the Operations Evaluation Group of Massachusetts Institute of Technology, has undertaken duties as Senior Scientist (Oceanographer) on the staff of the Inter-American Tropical Tuna Commission at La Jolla, California. He also has been appointed Research Associate of Scripps Institution of Oceanography.

EPHRAIM RADNER, formerly with the Geophysics Research Directorate of the Air Force Cambridge Research Center, has taken up duties as Vice President and Treasurer of the newly formed Geophysics Corporation of America.

ADRIAN E. SCHEIDEGGER, Research Associate with Imperial Oil Limited, Calgary, Canada, recently presented a two-week series of lectures in the Department of Geology and Geophysics at Massachusetts Institute of Technology, the title of the series being "Hydraulic Effects in Geodynamics." He has subsequently taken up duties as Visiting Professor at the Seismological Laboratory of the California Institute of Technology for an interval of six months.

HARRISON W. STRALEY, III, has sold his consulting business to GeoTek of Vero Beach, Florida, and has taken up duties as Exploration Manager

of the Mineral Development Program for Georgia Institute of Technology. He will continue on a consulting basis with GeoTek.

C. WARREN THORNTHWAITE, Director of the Laboratory of Climatology, Centerton, New Jersey, has been awarded the Cullum Geographical Medal of the American Geographical Society. The award is made for exceptional research in the field of geography and was formally presented to him on January 20.

FRANK L. WEAVER of the Federal Power Commission has recently been named by the International Joint Commission to become a member of the International Passamaquoddy Engineering Board.

HAROLD G. WILM, Associate Dean of the New York School of Forestry at Syracuse, and President of the Association of Hydrology, IUGG, has been appointed Commissioner of Conservation of the State of New York.

MURRAY ZELIKOFF, formerly with the Geophysics Research Directorate of the Air Force Cambridge Research Center, has taken up duties as Vice President and Director of Research of the newly formed Geophysics Corporation of America with headquarters in Boston.

HEBER B. CHURCHILL, retired, formerly Secretary of the Great American Insurance Company, died in New York City March 25, 1958 at the age of 92. He was born in Portland, Maine. His career was devoted to problems relating to insurance and his interest in geophysics was in this connection. Applications of seismology and the development of earthquake resistant structures, the study of wind storms and wind storm construction were his particular interests and during his lifetime accumulated a great collection on this subject which he presented permanently to the Insurance Society of New York. He became a member of AGU in 1949 at the age of 82.

JAMES B. CULLISON, JR., Manager of the Rain and Hail Departments of a group of fire insurance companies, died at Evanston, Illinois on February 2, 1958 at the age of 74. He was born in Muscatine, Iowa. He attended Oklahoma A. and M. College for two years and took a special course in law at the University of Chicago in 1921-1922. In 1917 he became Manager of the Hail Department of the Great American Insurance Company and in 1919 took up duties as the Manager of the Rain and Hail Department of the group of fire insurance companies and also President of the Crop-Hail Insurance Actuarial Association. His whole career was devoted to the matter of collecting data regarding weather conditions, particularly rainfall in various amounts and the frequency of hail storms, and the problems of hail insurance. He had been a member of AGU since 1948.

G. GALE DIXON, Chief Sanitary Engineer of the firm of Parsons, Brinckerhoff, Hall, and Macdon-

ald, and an associate of the firm, died December 6, 1958, at the age of 73. He was a graduate of the College of the City of New York, and during his career was involved in the design work of water and sewage facilities for New York, St. Louis, Houston, Philadelphia, Akron, and other cities. He served on the Board of Review with regard to water problems of Lake Michigan, and specifically on the plans for the West-Southwest Sewage Treatment Works for Chicago which has been judged to be one of the seven civil engineering wonders of the modern world. In AGU, he was a representative of the firm of Parsons, Brinckerhoff, Hall, and Macdonald in their corporation membership.

EMERAN J. KOLKMEYER, Professor of Physics at Canisius College in Buffalo and Director of the Seismic Station, died August 18, 1958 at the age of 64. After his education as a priest, he entered into scientific studies. In 1936 he was a member of an expedition to Russia to photograph the total eclipse of the Sun. From 1938 to 1940 he took up his first duties as Professor of Physics at Canisius College and took an important hand in the planning and instrumentation of a new Physics Building. From 1940 to 1944 he was Administrator of Brooklyn Preparatory School, then returning to Canisius College where he continued on various phases of educational work up to the time of his death. He had been a member of AGU since 1939.

ARTE LOYD MCCUSTION, owner and operator of Weather Computers of America in Tulsa, Oklahoma, died July 9, 1958 at the age of 54. He was born at Prairie Grove, Arkansas. He entered service with the Air Corps and Signal Corps of the U. S. Army in 1926 and after studies in meteorology he entered into the service of air lines as a forecaster in 1929, establishing his own office as Meteorological Consultant and serving as a teacher and director of the Spartan School of Meteorology for an interval beginning in 1932 and again from 1944 to 1953. In 1941 he took up duties as Chief of Academic Training at the Oklahoma Air College which trained 8000 pilots in weather fundamentals. In addition to his consulting meteorological work, since 1955 he had undertaken duties as Purchasing Agent for Tulsa County. He had been a member of AGU since 1948.

THOMAS JOSEPH MITCHELL, formerly a Geodetic Engineer with the U. S. Coast and Geodetic Survey and more recently Manager of the Poinsett Lumber and Manufacturing Co. of Picken, South Carolina, died December 29, 1958, at the age of 70. He was born at Carsonville, Michigan, and took his baccalaureate degree from the University of Michigan in 1912. He was with the U. S. Lake Survey from 1913 to 1933, Professor of Surveying and Geodesy at the University of Michigan from 1934 to 1937, and Geodetic Engineer with the U. S. Coast and Geodetic Survey from 1937 to 1939. He retired in 1939 and took up duties with the Poinsett Lumber and Manufacturing Co., where he retired from active work in 1956. He had been a member of AGU since 1938.

WILLIAM SCHRIEVER, Professor of Geophysics at the University of Oklahoma, died November 20, 1958, at the age of 64. He was born in Dakota City, Nebraska and received his baccalaureate degree from Morningside College in Iowa in 1916. He attended the University of Iowa where he took his master's degree in 1917 and following World War I renewed his studies and took his doctorate in 1921. He took up work at the University of Oklahoma the same year and advanced progressively to Professor in 1927 and served as Head of the Department of Physics from 1942 to 1952 and Director of the School of Engineering-Physics from 1942 to 1948. He had been a member of AGU since 1943.

TAISIA MAXIMOVA STADNICHENKO of the U. S. Geological Survey died November 26, 1958 at the age of 64. She was born in Taganash in the Crimea and graduated from Vladivostok Gymnasium in 1912 and the University of Petrograd in 1917. Her early work was with the Russian Geological Survey Expedition to the Sakhalin Islands off the east coast of Siberia. She came to the United States following World War I and for three years served as Professor of Chemistry at Vassar College. For six years she was Research Assistant of the National Research Council and the American Petroleum Institute. In 1931 she became a naturalized citizen, joining the staff of the U. S. Geological Survey. There she was engaged in geochemical work on germanium, beryllium, molybdenum, and other elements and was the author of numerous scientific papers. She was a member of AGU from 1945 to 1951.

HUBERT WILKINS, Consultant with the Quartermaster Research and Development Command at Natick, Massachusetts, died December 1, 1958 at the age of 70. He was born in South Australia and attended Adelaide University. He was knighted in 1928 and received many other honors and awards. His outstanding career as an explorer in the Arctic and Antarctic is so well known as to not warrant outlining it here. In responding to his passing, the AGU noted that he was a great explorer and scientist, conqueror of the last geographic frontiers, one of the great men of this century, and that he has left his heroic work, adding greatly to the world's fund of knowledge.

JACKSON H. WILKINSON, who retired from active duty as Hydraulic Engineer with the Tennessee Valley Authority in 1957, died November 29, 1958 at the age of 66. He was born at Bethany, Illinois, and took his baccalaureate degree from the University of Illinois in 1915, devoting an additional year in securing his master's degree in hydraulics. He served in the first World War and in subsequent years was engaged in work with the Fargo Engineering Company, the Illinois State Highway Department, the Morgan Engineering Company, and the State of Texas. He took up duties with the Tennessee Valley Authority in 1934 and headed up the work of the Hydrologic Data Branch for 18 years, subsequently devoting his last five years of active service to river forecasting problems. He had been a member of AGU since 1936.

Union, Section, and Committee Activities

Meeting of the Pacific Northwest Region

The Pacific Northwest Region held its annual meeting in Portland, Oregon, November 13-14, 1958, with a total registration of 80 but with about 150 persons attending one or more of the sessions. About 15 papers were presented on various subjects with the theme of the IGY receiving particular emphasis. The highlight of the meeting was an address on the subject "Scientific Exploration of Space" by William H. Pickering, Director of the

Jet Propulsion Laboratory of California Institute of Technology. A financial report indicated that the assets of the region were \$115.34 on July 1, 1958, and after the receipts and disbursements relating to the meeting in November, the balance was \$133.34. Details for this report were transmitted by Wilbur D. Simons, Chairman of the Pacific Northwest Regional Group.

Meeting of the Pacific Southwest Region

The Pacific Southwest Regional Group held its annual meeting at Stanford University, February 5-6, 1959; more than 200 were in attendance. About 120 attended the luncheon on February 5, at which an address was given by Ronald N. Bracewell, Associate Professor of Electrical Engineering at Stanford University, on the subject "The Future of Satellites." There was a good attendance on each of the three excursions scheduled for the afternoon of Friday, February 6. About 30 papers were presented, the abstracts of which will be published in the *Journal of Geophysical Research* in due course. The Chairman of the Regional Group is Vito A. Vanoni of California

Institute of Technology; the General Chairman for the meeting was Joseph B. Franzini of Stanford University; the Chairman of the Program Committee was Harold E. Thomas of the U. S. Geological Survey; and the Committee on Local Arrangements consisted of John K. Vennard and Byrne Perry. The Sections of Hydrology, Meteorology, and Oceanography joined in holding this meeting and expressed the feeling and hope that other Sections would join in subsequent years. The next meeting is planned to be held in January or February, 1960, the place of meeting not yet decided.

Meetings of the Geophysical Society of Hawaii

The Geophysical Society of Hawaii, which serves as the Mid-Pacific Region of the American Geophysical Union, has had a series of successful evening meetings during the winter months, including an address and the showing of a film on the erup-

tion of the Capelinhos Volcano on Fayal Island of the Azores by John Mulford, the scientific work of the Russian IGY ship *Wityaz*, and a panel discussion on the meteorological problems of the jet age.

Progress Report of the Committee for the Study of the Metric System in the United States

FLOYD W. HOUGH, *Chairman*

CARL I. ASLAKSON
FINN E. BRONNER
JOHN G. FERRIS

HELMUT E. LANDSBERG
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MILTON O. SCHMIDT
LANSING G. SIMMONS
GEORGE E. WHITMORE

L. V. JUDSON, *Consultant*

Pursuant to the resolution adopted unanimously at the business session of the American Geophysical Union on May 7, 1958 [*Trans.*, June 1958, p. 558], President Ewing appointed the above Committee.

Bills for the compulsory adoption of the metric system in the United States have been more than

once presented to Congress, but they failed, the principal reason probably being that the effective date proposed was entirely too soon after passage of the bill. An early effective date would undoubtedly work a severe hardship on the adult population not familiar with the metric system, and it would make obsolete a prohibitive amount of

everyday items of weights and measures. A solution would appear to be a bill to make the metric system the only official system of weights and measures in the United States, effective in not less than one generation, 33 or more years, after passage of the bill. Following this action by the Congress, the grade schools and high schools would begin immediately to teach children the metric along with the English system and, during the transition period, would place more and more emphasis on the metric system. By the end of the transition period, the English system would still be taught, but the emphasis would be completely reversed from what it is today. A long transition would result in a smooth change. In a generation, most items of equipment involving weights and measures normally become obsolete or worn out and are replaced. Also, persons engaged in professions and trades now using the English system exclusively would normally pass on to retirement during this period and would be replaced by a new gen-

eration thoroughly educated and trained in the metric system.

QUESTIONNAIRE

The questionnaire that follows below is directed to readers for the purpose of gathering statistical information to indicate the degree of interest in this matter. The Metric Committee of the American Geophysical Union will welcome any comments. Those submitting replies are urged to suggest solutions to difficulties which may be foreseen in the adoption of the metric system.

Additional copies of the questionnaire are available upon request to the Editor.

A small effort on your part to complete and mail this questionnaire will be of invaluable help to the Committee.

Detach the questionnaire, fill it in appropriately, and return promptly to the American Geophysical Union, 1515 Massachusetts Avenue, N.W., Washington 5, D. C.

Metric System Questionnaire

1. Indicate professional field of interest in the A. G. U. _____
2. What approximate percentages of units used in your work are: Metric _____ British _____ Other _____
3. Would it be to your advantage if a complete conversion to the metric system could eventually be made? Yes _____ No _____
4. How long a period of time should be allowed for the conversion, in years? 10 _____ 20 _____ 30 _____ 40 _____ 50 _____ Longer _____
5. Should the centigrade system of temperature measurement be adopted? Yes _____ No _____
6. Do you believe that U.S. export trade is suffering because of the use of English units? Yes _____ No _____ No opinion _____
7. Do you believe that the eventual adoption of the metric system is inevitable? Yes _____ No _____
8. In the event of a long time conversion to the metric system do you believe that the cost would be prohibitive? Yes _____ No _____
9. In the event a committee were established to study the problem, circulate questionnaires, accumulate statistics, and report: It should be sponsored by _____

- ☐ professional societies
☐ educational institutions
☐ industry
☐ government

How should the study be financed? _____

Would you be willing to assist such a study group? _____

- ☐ financially
☐ as an advisor

10. Additional remarks at any length are welcomed _____

Signature (omit if you prefer)

SPECIAL ANNOUNCEMENTS

FORTIETH ANNUAL MEETING TO BE HELD IN WASHINGTON, MAY 4-7, 1959—Last-minute attention is called to previous announcements regarding the Fortieth Annual Meeting to be held in Washington, D. C., May 4-7, 1959. The program is now closed and will be mailed to all members and subscribers at an early date. Attention is called to the December, 1958 *Transactions*, page 1200, for information regarding hotel rooms. Bear in mind that advance bookings on which deposits have not been made are usually canceled two weeks in advance, and thus during this interval the chance of making your reservation may be quite good. Although you make no advance arrangements for quarters, it is usually possible to do so after you arrive in Washington through the Housing Committee of the Washington Board of Trade (1616 K Street, N.W., Washington, D. C., telephone REpublic 7-2600); but they may find it necessary to direct you to a tourist home.

NEW MEMBERSHIP PLAN OF THE INSTITUTE OF RADIO ENGINEERS—The Institute of Radio Engineers has announced an Affiliate Plan under which members of AGU are entitled to become affiliated with and receive the publications of some of the professional groups of IRE without the need to join IRE itself. They need to pay only the regular Professional Group dues plus \$4.50 rather than the full Institute membership fee. Members of the AGU have been approved for affiliation with the Professional Group on Information Theory (PGIT), the dues for which are \$3.00 per year. Members interested should get into touch with The Institute of Radio Engineers, 1 East 79th Street, New York 21, New York, Attention: E. R. Kretzner, Chairman of the Membership and Chapter Activities Committee of the Professional Group on Information Theory.

TWELFTH GENERAL ASSEMBLY OF IUGG—As announced earlier, the Twelfth General Assembly of the International Union of Geodesy and Geophysics will be held in Helsinki, Finland, July 25 to August 6, 1960. United States citizens who would like to present a paper or who are planning to attend should get into touch with the office of the American Geophysical Union (1515 Massachusetts Avenue, N.W., Washington 5, D. C.) as

promptly as possible. The formal invitation from Finland has arrived, and a supply of the First Circular, issued by the Finnish Arrangements Committee, has recently been received and will be sent to those who have indicated plans to attend.

Definitive details of the program are being planned by each of the seven Associations and by the Union as a whole. The formal opening session will be held on the morning of Monday, July 25, with addresses by the Finnish officials, the address of the President of the IUGG, and the report of the General Secretary. The first sessions of the Associations will follow on the afternoon of the same day. The final plenary session will be held on Saturday morning, August 6.

The place of meeting will be in three buildings of Helsinki University: Porthania, the Main Building, and the Forestry Building, all of which are located within 400 meters of the center of the old city. Registration and the general administration of the Assembly will be in Porthania, where meals likewise will be served. Hotels are within a distance of a kilometer of the meeting place, but student residences are situated farther away.

Excursions are planned to various observatories, and after the meeting there will be an opportunity to visit Lapland beyond the Arctic Circle.

Watch **Special Announcements** for further details.

PLANS FOR THE ENGLISH EDITION OF *Izvestiya*, GEOPHYSICS SERIES—Bulletin (*Izvestiya*), *Geophysics Series*, of the Academy of Sciences, USSR, will be published in an English edition by the AGU for the calendar year 1958, according to present plans. Subscriptions (\$25.00 for the 12 numbers to be issued during 1958) with payment should be sent direct to the American Geophysical Union. *Izvestiya* for 1957 has been produced by Pergamon Press under arrangements with the American Geophysical Union. Orders for these may likewise be sent to the American Geophysical Union. The price is the same except for the addition of a service charge of \$3.00. A special introductory offer to individuals ordering these for their personal use of \$12.50 for each year (plus the service charge for the back numbers) is available as an introductory offer only.

NATIONAL ACADEMY OF SCIENCES

Number 19 • January 1959

IGY BULLETIN

A monthly survey by the U. S. National Committee for the International Geophysical Year. Established by and part of the National Academy of Sciences, the Committee is responsible for the U. S. International Geophysical Year program in which several hundred American scientists are participating and many public and private institutions are cooperating.

Use of a Temperature Telemetering System in Incubating Eggs of Antarctic Birds

This report is based on material supplied by Carl R. Eklund, Scientific Leader at US-IGY Wilkes Station during 1957-58, and Frederick E. Charlton, Electronics Technician Chief, USN. Part of the data is being used by Eklund in a doctorate thesis at the University of Maryland.

Ever since the Emperor Penguin (*Aptenodytes forsteri*) was first found incubating its eggs in the Antarctic in temperatures as low as 77° below zero Fahrenheit, students of animal physiology have wondered how the embryos could develop in such cold. Establishment of stations in Antarctica by the United States during the IGY provided a rare opportunity to carry out studies of this question.

Because the Emperor has no fixed nest and may move many times while incubating an egg, a temperature instrument that could be contained within the egg was needed. Fortunately, the Office of Naval Research was contracting at this time for a miniature telemetering instrument to be used in human physiology studies. It would be ideal for the proposed work on polar animals.

The instruments were delivered in time for use during 1957 at the US-IGY Wilkes Station, located among the Windmill Is-

lands of Vincennes Bay, on the Budd Coast of Wilkes Land, at 66°15'S, 110°31'E.

The area turned out to be very rich zoologically, but unfortunately no Emperor Penguins were nesting in the region. It was decided, therefore, to carry out the temperature studies on summer-nesting species such as the Adelie Penguin (*Pygoscelis adeliae*) and the South Polar Skua (*Catharacta maccormicki*). The studies were conducted over a 9-day period, December 11-19, 1957, at Adelie Penguin Rookery "A," on Clark Peninsula one-quarter mile from Wilkes Station.

An Adelie Penguin egg and a skua egg were emptied by cutting them in half lengthwise with an electric saw of the type used in handicraft work.

A tiny, elliptical moisture-proof transmitter was placed between the two halves of each eggshell and the edges cemented together. After the cemented eggs had dried, 30 cc of albumen were injected by syringe through 1/16-inch holes at the tops of the eggs, and the holes sealed with cement.

A transmitting egg, carefully calibrated against a standard thermometer, was substituted for one of the normal clutch of two in each nest. The second or normal egg acted as a control, and since it eventually hatched in each instance, this was taken as

indicative that the experimental egg had received a normal temperature. (Each transmitting egg was recalibrated on completion of the study.)

Each transmitter radiated a modulated electromagnetic signal, the number of pulses per second being proportional to the temperature inside the egg. This signal was intercepted by a loop antenna placed over the nest and relayed by transmission line to a low-frequency radio receiver in a nearby observers' shelter. There it was demodulated and sent to a pulse counter.

This unit, read at 15-min intervals, reflected temperature changes in the incubating egg within limits of 41° to 104°F. The study showed the average temperature of the incubating skua egg to be 96.6°F, with a maximum of 103.5°F and a minimum of 87°F. The average body temperature of this species is 106.1°F, ranging from a minimum of 103.4°F to a maximum of 108.4°F. The average temperature of the incubating egg was thus 9.5°F less than the average skua body temperature.

The average temperature of the incubating Adelie Penguin egg was 92.7°F, with a maximum of 98.2°F and a minimum of 84.6°F. The average body temperature of the Adelie is 103.8°F, ranging from a minimum of 100.3°F to a maximum of 106.4°F. Thus the average temperature of the incubating egg of the Adelie was 11.1°F less than its average body temperature, and 3.9°F

less than the average temperature of the incubating skua egg.

The greater range in the incubating temperatures of the skua egg reflects the number of times the parent bird changed incubation duties with its mate. One of the pair of skuas under study was sprayed with green paint to provide easy differentiation of both birds on the nest. A continuous 132-hr record was kept; during this period the pair relieved each other in the nest 13 times, or an average of 2.36 times every 24 hrs. The Adelie Penguin, on the other hand, may not be relieved by its mate for as long as two weeks.

On the basis of temperature studies conducted on chicken embryos by C. Romijn and W. Lokhorst, it was found that a rise in body temperature of the embryo may be expected after the tenth day of incubation (about the first half of the total time required), when the heat production of the chick embryo increases rapidly. If similar action took place in the egg of the skua and the penguin, the temperatures obtained in this study would be valid only up to about the first 10 to 15 days, after which they would be affected by the embryo.

The theory of application and the basic design of the temperature telemeter were excellent for the work carried out, and it is believed that the instrument has possibilities for remote temperature studies in the field of physiology generally.

Reports on IGY Solar Eclipse Expedition

This report is based on material supplied by Herbert Friedman, Superintendent of the Atmosphere and Astrophysics Division, Naval Research Laboratory; Robert J. Lou, Executive Officer, High Altitude Observatory; and Garth Stonehocker, Central Radio Propagation Laboratory, National Bureau of Standards.

The US-IGY expedition to the Danger Islands in the South Seas to observe the solar eclipse of October 12 was the most elaborate such expedition ever mounted (see *Bulletin No. 12*).

In addition to a scientific team aboard the USS *Point Defiance*, to handle the rocket experiment, there were five groups

of experimenters based on the islands. Herbert Friedman led the shipboard group of ten scientists and engineers from the Naval Research Laboratory. These included Talbot A. Chubb, John C. Lindsay, and Robert W. Kreplin, who were responsible for various phases of the rocket astronomy program. In the mounting and arming of the rockets, this group was assisted by Robert E. Cox and two engineers of the Cooper Development Corp. of Monrovia, California.

On the shore, John W. Evans of Sacramento Peak Observatory, Sunspot, New Mexico, led a group of 16 scientists from the High Altitude Observatory, the Central Radio Propagation Laboratory of the National Bureau of Standards, the University of Wisconsin, the California Academy of Sciences, and the Naval Radiological Defense Laboratory. Assisting the scientists were teams of Navy and Marine Corps specialists, including an underwater demolition team of seven frogmen, nine marines to pilot amphibious craft, and three helicopter pilots with a ten-man supporting group.

In addition to the American effort, a British and New Zealand expedition established a base on Atofu, a Japanese expedition took station on Suvarrow Island, and a Swiss party made observations on the coast of Chile.

Eight US observation and test projects were planned. Of these, four required clear skies and another required at least partly clear weather. Clouds obscured the sun just long enough to destroy these four experiments and seriously limit the validity of the measurements obtained by the fifth.

Three experiments could be carried out regardless of cloud cover; these were all successful. The NRL rocket flights, in particular, were an outstanding success. The Sacramento Peak-High Altitude Observatory group recorded changes in cosmic noise absorption at 18.5 mc/s, supplemented by observations of atmospherics received at 27 kc/s. (Atmospherics are radio

signals originating in naturally-occurring electrical discharges in the earth's atmosphere, such as lightning flashes.) In addition, a very good set of ionospheric soundings with a C-2 vertical-incidence sounder was made by personnel of the NBS Boulder Laboratories (see Fig. 1).

Optical Experiments

The optical experiments that stood idle under the cloud-filled sky were intended to make line-profile measurements of the green and yellow emission lines of the sun's corona, to detect the polarization of the white light corona, to observe quantita-

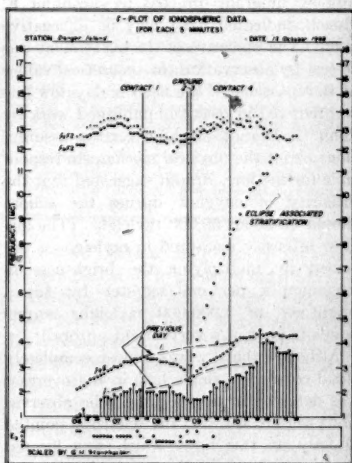


Fig. 1. Graph of Frequency Against Time (*f*-plot) for the Eclipse Period, 0800-1130 Local Time, at 165°W. Sampling interval is five min. Both the critical frequency of the E-layer (f_oE) and the f -minimum started decreasing after first contact, dipped sharply near totality, then recovered to their normal values for that time of day. A stratification developed just above the E-layer and increased in both critical frequency and virtual height until it combined with the F2-layer critical frequency (f_oF2), about 1100; this phenomenon is usual during eclipses.

tively, for the first time, "shadow bands" thought to be produced by variations in the earth's atmosphere, and, finally, to photograph rapid-sequence, medium-dispersion spectra of the chromosphere, the lowest layer of the sun's atmosphere.

A fifth experiment, an attempt by the National Bureau of Standards' Boulder Laboratories to observe the 6300 Å neutral oxygen emission line of the daytime airglow, was partially successful in spite of the clouds.

Airglow studies: The airglow observations, carried out by Lawrence R. Megill and Edward Marovich of NBS, who have been working for some time in the NBS airglow program directed by Franklin E. Roach, indicated what may be a negative result. The objective of the experiment was to test by observation the theoretical values of the intensity of the 6300 Å dayglow line as predicted in recent unpublished work by John C. Brandt. Making certain assumptions about the physical mechanism responsible for the line, Brandt suggested that the intensity of dayglow during the eclipse should be about 50,000 rayleighs. (The airglow intensity measured in rayleighs is obtained by multiplying the brightness in megaquanta per $\text{cm}^2/\text{sec}/\text{ster}$ by 4π ; a brightness of 1,000,000 rayleighs corresponds to that of a very bright aurora.)

Although the sky was almost completely cloud-covered, a single hole in the overcast was detected at eclipse time. The observations were made with the telescope pointed directly at this hole, which was located reasonably far from the sun but not as far as would have been desirable for the optimum detection of a terrestrial atmospheric-emission phenomenon.

The intensity of the radiation received was below the threshold of the instrument. This suggests that an upper limit may be established for the intensity of the line at a value substantially less than the predicted value, but the observational result is not easy to interpret because of the difficulty

of determining quantitatively the effect of the clouds. This effect will strongly influence the calibration of the instrument; thus, at the present time the implications of the observation are uncertain. An effort is being made to untangle the conflicting factors.

Rocket Experiments

The rocket experiments were designed to measure X-ray and ultraviolet emissions from those portions of the sun which were uncovered during various stages of the eclipse. As an eclipse progresses, it is possible to measure the contributions of sunspot regions as they are covered or uncovered. During totality, the photosphere is completely covered and any residual radiation must come from the outermost layers of the chromosphere and from the corona. If a rocket is in the air for a few minutes leading up to second contact (when the moon covers the sun and the corona becomes visible) and for a corresponding interval just after third contact (when the sun begins to reappear), its detectors should see the variation of emission with altitude above the sun's limb, or edge, up to the top of the chromosphere and perhaps into the inner corona.

Rocketry: The Nike-Asp rocket combination selected for the experiment underwent a series of five test launchings from San Nicolas Island, California, during July and appeared to be well suited for the eclipse experiment. The Nike booster burns for about 3 sec, to a height of about 1 mi, where differential air drag separates the Asp from the booster. The Asp coasts to a height of 40,000 ft before it ignites. After burning for six seconds, the Asp reaches an altitude of 800,000 ft with its 75-lb payload and falls back to earth after a total flight time of 8 min.

A rocket operation aboard ship introduces certain difficulties. To avoid azimuth deviations in launching direction, it was necessary to fire when the ship was horizontal. This

was accomplished by the use of a gyro-stabilizer which delayed the firing signal until the ship was horizontal within $\pm 1/4^\circ$. Since the rockets could not have been safely handled in a rough sea, all mounting work was accomplished while the ship was docked in Samoa. Instrumentation sections were installed the day before the eclipse. Finally, expert navigation was required to locate the ship at the planned launching position, 40 mi from Pukapuka, at exactly the proper time.

Instrumentation: The instrumentation units for the rockets were equipped with detectors to measure X-rays in two wavelength bands, 8-18 Å and 44-60 Å, and Lyman-alpha emission of hydrogen in the ultraviolet at 1216 Å. Photocell units were included to permit determination of rocket aspect throughout flight. Bendix FM-FM telemetering was employed, using frequencies of 228.5 and 219.5 mc/sec at 2 watts power output with four sub-carrier channels. Telemetered signals were received by means of antennas mounted in the muzzles of pairs of 3-in guns which could be trained to follow the flights of the rockets. Tape and oscillograph recordings were made in a trailer in the ship's well deck.

Shipboard Experiment: It was originally planned to launch two rockets for test purposes and background data on September 28 and October 1 and to launch six rockets on October 12 during the progress of the eclipse. Two of the six eclipse rockets were to be in the air during totality and the remaining four were to be distributed so as to observe portions of the disk exposed before second contact and after third contact.

On the day of the eclipse, the distribution of visible activity on the disk of the sun was as illustrated in Figure 2. It was then decided to launch the first rocket about 10 min before second contact to expose a crescent on the east limb containing a number of sunspots. The second and third rockets were to be fired during totality. Shortly

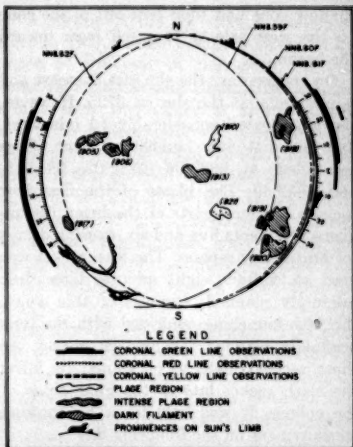


Fig. 2. Appearance of Solar Disc on October 12, 1953. Dashed lines show edges of moon's disc projected on sun's disc at times of first four rocket launchings. Plage numbers (in parentheses) assigned by McMath-Hulbert Observatory. All data other than sunspot locations by High Altitude Observatory, Boulder, Colorado.

after third contact, the fourth rocket was to be launched so as to measure radiation from a crescent of the disk on the west limb. This portion was clear of activity except for a prominence. The fifth and sixth shots were to follow the fourth at 10-min intervals.

The rockets were mounted on fixed launchers spaced in a pattern about the helicopter deck. Since the rocket measurements were to be made at ionospheric altitudes, it was necessary to shoot from outside the ground level shadow. At eclipse time the ship was headed on a course of $115^\circ 40'$ northeast of Pukapuka at approximately $10^\circ 21'S$, $165^\circ 28.8'W$. The totality rockets were launched at an azimuthal angle of 295° in order to enter the eclipse shadow cone from the east at an altitude of about 120 mi. Assuming ideal performance, the rockets would reach a 150-mi altitude inside the

shadow cone and then pass out of the cone on the west side as they fell back toward the ocean.

On eclipse day, the sky was overcast and rain squalls hit the ship at 0725. However, the sky cleared considerably 15 min later, and the first four launchings went off as scheduled, at 0832:06, 0842:03, 0843:18, and 0852:49. The blasts of the first four rockets loosened parts of the firing mechanisms of rockets five and six, causing delays for emergency repairs. The fifth rocket was fired at 2010:09, eight minutes later than originally planned. Because of this delay, the fifth launching coincided with the time originally planned for the last rocket. As there seemed little to be gained by firing the sixth rocket late in the final phase of the eclipse, it was held for a background measurement on the following day.

Preliminary examination of the telemetering records showed that the five rockets fired on the day of the eclipse reached peak altitudes of 139, 148, 152, 150, and 55 mi. The Lyman-alpha radiation appeared to follow the un eclipsed area of the disk very closely and almost disappeared within a few seconds after the rockets entered totality. In strong contrast, a residual flux of soft (50 Angstrom) X-rays persisted throughout totality. Measurements before second and after third contacts showed great limb-brightening in X-rays. The X-ray emission strongly resembled the kind of intensity distribution observed in radio decimeter wave measurements. Thus, the sun appears to be ringed by a bright X-ray halo.

Totality Launchings: In the totality launchings, an attempt was made to scan the region about the sun in Lyman-alpha light with an angular resolution of about 3° of arc. Unfortunately, the two totality rockets were very stable and neither developed enough yaw to scan closer than 7° to the sun. At that distance, some Lyman-alpha signal was evident in the record but

quantitative evaluation of its intensity will require careful analysis of the data.

The aspect indicators used in the totality launchings were photomultiplier tubes which viewed the sky through gunsight-type reticles. The photomultipliers, which were set to receive a flux equal to half of that of full moon in the visible spectrum, were heavily over-exposed. It appeared that the airglow in the totality cone remained very high and was responsible for saturating the photomultiplier response.

Detailed analysis of the telemetering records should yield quantitative information on the residual flux of X-rays at totality. Any asymmetry produced by the presence of sunspots on the east limb and their absence on the west limb should be apparent in data recorded in the first and fourth rocket flights.

Flare Data: Unexpected data were received when the last rocket was fired, at 0839:56 on October 13. Although the shipboard group did not know it at the time, a class 2+ flare was in progress. The rocket reached peak altitude during the flare shortly after a maximum of sudden cosmic noise absorption was recorded on the island by Robert Lee, of the HAO group. The rocket performed exceptionally well and good data were received on X-ray fluxes in the 8-18 Å and 44-60 Å bands as well as on Lyman-alpha. The latter showed no significant variation, but the X-ray fluxes were strongly enhanced.

The degree of success achieved in this first attempt to apply rocket astronomy to the study of a solar eclipse should encourage more diversified measurements in future eclipses. It will be interesting to compare the residual X-ray flux measured at the minimum of the solar cycle with the flux observed at maximum in this year's eclipse. It is well known that the corona assumes a more or less symmetrical shape near maximum, but takes the form of long equatorial streamers at minimum. The air-

glow at totality with respect to both time and geometry would be another interesting phenomenon to scan from rocket altitudes.

Cosmic-Noise Absorption and Atmospheric Experiments

Another experiment which succeeded despite the clouds was conducted by the Sacramento Peak-High Altitude Observatory group with a device built by HAO for indirect detection of solar flares during the IGY. The detector is a "cloud-proof" instrument that measures by radio means the effects on the terrestrial ionosphere caused by enhanced short-wave radiation from the flare.

Equipment and Technique: One of the units of the detector, the SCNA (sudden cosmic-noise absorption recorder), measures at 18.5 mc/s the intensity of cosmic noise received from overhead. During a flare, ionization in the lower E-region is enhanced, causing an abrupt increase in absorption of the signal received. At the same time, the SEA (sudden enhancement of atmospheric recorder) measures the intensity of radio noise at 27 kc/s, primarily from distant thunderstorms, propagated to the antenna by D-region reflection. During a flare, the efficiency of the D-region as a mechanism for propagation of radio signals is increased, and the intensity of received atmospheric is thus enhanced. In this way, a flare is signalled by a simultaneous increase in the level of the records at 27 kc/s and a decrease at 18.5 mc/s.

Three of the SEA-SCNA instruments were built for the world-wide IGY flare detection network. One was completed in time to be taken by the Sacramento Peak-HAO group to the Danger Islands. (It was left in Hawaii on the return trip and went into operation there October 30.)

Technical Problems: Some difficulties attended operation of the equipment at Danger Island. First, the antenna was "looking

at" a portion of the sky that is relatively quiet in 18.5 mc/sec cosmic noise at that season of the year in the south-Pacific. Moreover, the daytime tropical ionosphere admits such frequencies of cosmic noise only to an angle of approximately 45° from the zenith; at this angle, the antenna includes within its field a portion of the E-region of the ionosphere that is not inside the region of totality. Furthermore, during the eclipse, the antenna was directed in part at a region of the ionosphere that was in total shadow for only a short time, if at all.

There were other difficulties. The site was, as anticipated, electronically noisy. In addition, voltage regulation of the power supply was poor. The effects of these difficulties were reduced to tolerable levels. However, the great density of broadcast interference in the 18-mc/s band caused additional difficulties; the Danger Islands appeared to be just the right distance from both Europe and North America to pick up a maximum of signals from stations in these areas. The SEA records, finally, proved to be of little value, probably because the principal atmospheric-producing thunderstorms were much too close at hand.

Results: In spite of these problems, useful results were obtained with the SCNA. The equipment was operated nearly continuously at the island from September 15 through October 17. Although there are inherent difficulties, it may be possible, even given the low recording level at the SCNA frequency, to distinguish in the records the daily sequence of cosmic-noise intensity by separating out, among other things, the ionospheric effects. Moreover, records of satisfactory quality were obtained on days before and after the eclipse; these provide suitable average, or standard, days for comparison with the eclipse records. In addition, records were obtained for a few days when there was high solar activity. It will be extremely interesting to compare these

with corresponding active-day records from the three SEA-SCNA instruments in the continental United States to determine if latitude and longitude effects can be discovered.

The records obtained during the eclipse itself were of good quality. Electronic noise was held to a minimum, but the need to use a short instrument time constant (because of the voltage regulation and electronic noise problems) renders the results difficult to interpret. Other factors, such as the reception of signals from near the edge of the cone of totality, also complicate the interpretation. No major in-

crease in signal strength (i.e., decrease in radio-wave absorption) was recorded during the eclipse. There was a very small decrease between first and second contact, and a very small increase at totality, but it is impossible to say now whether these were real. It is possible that the absence of a major increase is evidence that X-radiation rather than Lyman-alpha is the principal ionizing agent in the lower E-region (assuming that X-rays coming primarily from the corona would be incident on the earth's atmosphere throughout the eclipse), but it is still very premature to suggest that this is the correct inference.

Trans-Antarctic Trough

The following report is based on material furnished by Albert P. Crary, Deputy Chief Scientist of the US-IGY Antarctic Program.

New evidence that East and West Antarctica may be separated by a deep, ice-filled trough was provided by the discovery recently of the greatest bottom depth yet found beneath the Ross Ice Shelf (see Fig. 3). The record depth of about 4400 ft below sea level was measured by a seismic sounding at 79°06'S, 165°30'E, during the IGY Ross Ice Shelf-Victoria Land oversnow traverse of the 1958-59 Antarctic summer season.

(The traverse, led by Albert P. Crary, left IGY Little America Station on October 15, 1958, and is expected to terminate at the Naval Air Facility, McMurdo Sound, on February 4, 1959.)

If the sounding represents a major depression in the sea floor rather than a minor feature of limited extent, it may support a 50-year-old theory that a deep trough extends beneath the vast ice sheet from the Weddell Sea to the Ross Sea, cutting Antarctica in two. The 4400-ft depth is more than twice the greatest previous sounding under the Ross Ice Shelf, which extends some 400 mi into the Ross Sea embayment

from a point about 300 mi from the South Pole. Seismic studies by IGY scientists last year showed the ocean bottom to be about 2070 to 2155 ft below the ice surface.

The new low was found at a point 48 mi south of Mount Discovery and 90 mi south-

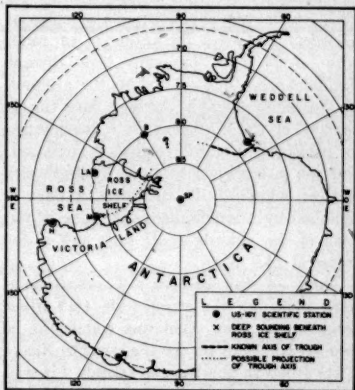


Fig. 3. Possible Location of Hypothetical Antarctic Trough. US-IGY Antarctic Stations are Byrd (B), Little America (LA), Ellsworth (E), Wilkes (W), South Pole (SP), and the Naval Air Facility, McMurdo (M); the cooperative NZ-US Hallett Station is designated (H).

southwest of the US Naval Air Facility at McMurdo Sound. The location would be a logical one, the traverse members feel, for a Pacific extension of the trough.

The record depth in the Ross Sea was discovered as the traverse neared the Skelton Glacier, which it ascended to the Victoria Land plateau.

The primary purposes of the Little America Station traverse this year are to study the snow and ice characteristics and obtain thicknesses over as long a line as possible into the main Antarctic highlands; to study the 100-mi-long Skelton Glacier and the geophysical aspects of the transition from the low-lying ice shelf to the high plateau; and to study in detail some anomalous water depths between IGY Little America Station and Minna Bluff, near the head of McMurdo Sound.

Antarctic Geography and Geology

The existence of an Antarctic trans-continental trough separating East and West Antarctica was first postulated by Griffith Taylor, geologist with the 1901-04 British National Antarctic Expedition, led by Robert F. Scott. Taylor based his theory on studies of Antarctic geography and the geology and geography of the nearby continents of South America and Australia.

Antarctica may be divided into two distinct segments on the basis of its geographic and geologic character. East Antarctica lies mostly east of the 0°-180° meridian, and hence is mostly within the eastern hemisphere. It consists of a vast, elevated "shield" of Pre-Cambrian rocks—rocks over 500 million years old. This very ancient "basement complex" is composed essentially of metamorphic rocks intruded by igneous rocks. These are overlaid by a thick series of younger, flat-lying sedimentary rocks, also intruded in many places by igneous materials. Upon these rests the great ice sheet of the south polar plateau.

West Antarctica is characterized primarily by folded ranges and plateaus of

metamorphic rocks and igneous intrusives similar to those of the Andes of South America. These are also overlaid by younger sediments and the thick mantle of Antarctic ice. The structure of West Antarctica can be traced through the Palmer Peninsula and the sub-oceanic Scotia Arc to the Andes.

The edge of the East Antarctic shield along the Ross Sea has been found to be a horst region—a linear block of the earth's crust that has been uplifted along faults, or breaks in the crust. This horst zone may extend completely across the continent to the Weddell Sea. Such structures are generally paralleled by down-dropped, trough-like blocks called grabens. Other examples of this horst and graben structure are the Rhine Valley of Germany and parts of the "basin and range" region of the Western United States.

The existence of the trough is also suggested by the deep penetration into the interior of Antarctica of the Ross Sea, on the Pacific side of the continent, and the Weddell Sea, on the Atlantic side.

Related IGY Findings

An IGY scientific traverse party from Ellsworth Station on the Weddell Sea coast last year detected a deep trough extending inland from the Filchner Ice Shelf (see *Bulletin No. 14*). The bottom of the trough was found to average almost 4000 ft below sea level, and the traverse party reported that the trough continued beyond the southerly limits of the traverse, swinging toward the southwest. This may represent the Weddell Sea side of the hypothetical trans-Antarctic trough (Fig. 3).

At approximately 80°15'S, 113°W, near the end of the final leg of the 1957-58 US-IGY oversnow traverse from Byrd Station, the surface beneath the 14,000-ft thick ice sheet was found to be more than 8000 ft below sea level (see *Bulletins 10 and 14*).

Further Studies

Further work is in progress during the present Antarctic summer to determine

whether the trough extends all the way to the deep basin discovered earlier in Marie Byrd Land and from there to the Ross Sea. A Byrd IGY Station traverse, led by Charles R. Bentley, is now en route to the Horlick Mountains, which extend eastward from the southeast corner of the Ross Ice Shelf, making geophysical studies that are expected to help solve the problem

of the trough's existence and exact location. An IGY airborne traverse is about to launch a series of seismic and gravity measurements in Marie Byrd Land to seek further evidence as to whether the ice-filled basin found there by members of the 1957-58 Byrd Station traverse may be part of the hypothetical trough connecting the Ross and Weddell Seas.

World Warning Agency Decisions

July 1—September 30, 1958

Bulletins 2, 5, and 10 describe the IGY World Days Program and the function of the IGY World Warning Agency (AGIWARN); Bulletins 5, 10, and 14 list earlier AGIWARN decisions.

Although the over-all level of solar activity was fairly high throughout the period July 1–September 30, 1958, geomagnetic conditions varied considerably. Geomagnetic activity was high in July, being exceeded only during two other months since the IGY began on July 1, 1957. In August, there was a sharp drop. September showed about the same average level of activity as August, but its median level was the lowest of any month yet recorded during the IGY; this was owing to two extremely quiet periods, September 10–15 and 18–24.

Eleven geomagnetic disturbances occurred, well distributed through the entire period. Three severe geomagnetic storms were observed, one during each of the three months. Eight of the 11 disturbances occurred during the seven periods of Alert that were declared by AGIWARN, and only one Alert was not followed by a storm. Of the five Special World Intervals (SWI) that were in effect, totaling nine days, only one was not followed by a disturbance. Two of the three severe geomagnetic storms occurred during SWI.

A list of Alerts, SWI, major geomagnetic disturbances, and major flares that occurred between July 1 and September 30, 1958, follows, with the Alerts numbered chronologically from #27, which ended on June 23, and the SWI from #13, which ended on June 22, 1958.

Jul	5	1600	Alert #28 starts
	7	0039	Class 3+ flare; gradual ionospheric disturbance
	8	0001	SWI #14 starts
		0619	Class 3 flare
		0749	Geomagnetic storm begins
	9	2359	SWI #19 finishes
	10	06xx	Geomagnetic storm ends
	11	0752	Class 3 flare
		0825	Class 3 flare
	14	1600	Alert #28 finishes
Jul	20	0636	Class 3 flare
		1203	Class 3 flare
		1600	Alert #29 starts
	21	1638	Geomagnetic storm begins
	22	1600	Alert #29 finishes
		23xx	Geomagnetic storm ends
Jul	23	1131	Class 3 flare
	24	1600	Alert #30 starts
	27	0856	Class 3 flare
	29	0303	Class 3 flare; sudden ionosphere drop-out and gradual recovery
	30	0001	SWI #15 starts
	31	2359	SWI #15 finishes
Aug	4	0421	Class 3 flare; gradual ionospheric disturbance
		1600	Alert #30 finishes
Aug	7	1500	Class 3 flare; sudden ionosphere drop-out and gradual recovery
Aug	11	1600	Alert #31 starts
	15	1600	Alert #31 finishes

Aug 16	0432	Class 3+ flare; sudden ionosphere drop-out and gradual recovery	7	1448	Class 3+ flare; sudden ionosphere drop-out and gradual recovery
	1600	Alert #32 starts	9	1425	Class 3+ flare
17	0001	SWI #16 starts	10	1600	Alert #34 starts
	0623	Magnetic storm begins	12	0908	Class 3 flare
18	17xx	Magnetic storm ends	13	0911	Class 3 flare
	2359	SWI #16 finishes	14	0832	Class 3+ flare; sudden ionosphere drop-out and gradual recovery
20	0043	Class 3 flare; sudden ionosphere drop-out and gradual recovery	16	1444	Class 3 flare; sudden ionosphere drop-out and gradual recovery
22	1417	Class 3 flare	18	0730	Class 3 flare; sudden ionosphere drop-out and gradual recovery
23	1013	Class 3 flare		1600	Alert #34 finishes
24	0001	SWI #17 starts	Sept 25	0408	Magnetic storm begins
	0140	Magnetic storm begins	26	11xx	Magnetic storm ends
	2359	SWI #17 finishes			
25	15xx	Magnetic storm ends			
	1600	Alert #32 finishes			
Aug 26	0005	Class 3 flare; slow ionospheric disturbance			
	1600	Alert #33 starts			
27	0001	SWI #18 starts			
	02xx	Magnetic storm begins			
28	00xx	Magnetic storm ends			
	2359	SWI #18 finishes			
29	1600	Alert #33 finishes			
Aug 30	1943	Class 3 flare, gradual ionospheric disturbance			
Sept 3	0842	Magnetic storm begins			
6	00xx	Magnetic storm ends			

A meeting of the Working Group for World Days and Communications was held at the Fifth IGY Assembly, in Moscow, July 29–August 9, 1958. It was the consensus among representatives of all participating disciplines that the World Days Program has been highly successful, and it was recommended that similar programs carry on this work on an international basis after the close of the IGY.

Apogee Moonwatch Stations

Material for this report was furnished by Richard Tousey, Naval Research Laboratory, Washington. D. C.

The standard $5\frac{1}{2}$ -power telescope used in the IGY Moonwatch program for visual observation of satellites can detect objects as faint as 8th magnitude against a dark nighttime sky. (Magnitude is a measure of star brightness used by astronomers; the higher the number the fainter the object.) This corresponds to the ability to detect a polished 21-in sphere approximately 750 mi above the surface of the earth at the observer's zenith. However, calculations prior to the IGY showed that some US satellites might rise as high as 2500 mi at apogee (the point in the orbit farthest from earth). The 6-in Vanguard test sphere, 1958 Beta 2, reaches almost this height at apogee. At this height, a 21-in sphere would appear no brighter than 11th magnitude when at the zenith.

Satellites viewed at low angles above the horizon would be even fainter than 11th magnitude because of the increased distance from the observer and the increased thickness of atmosphere through which the light reflected by the satellite must penetrate. Moreover, the visibility of a satellite depends not only on its brightness and its elevation above the horizon but also on the ability of the human eye to detect a faint object moving through the twilight sky or past the fixed stars at night. To insure maximum coverage of newly launched satellites with high orbits, eight "apogee" stations using specially designed high-power telescopes have been set up at strategic locations.

When the need for improved observation first became apparent the Naval Research Laboratory constructed a "satellite simulator," which presents to the observer an image similar to that actually made by a

satellite moving across the sky. All elements of the scene shown in the simulator are adjustable. The luminosity of the sky background, the brightness and number of stars in the field, and the brightness, altitude, and movement of the satellite can be varied to reproduce any desired situation. Figure 4 shows the optical arrangement of the simulator.

The Telescope

Experiments with the simulator showed that an 8-power telescope such as the US Army M-17 elbow telescope can detect a 21-in satellite at heights of 1000-1200 mi. For viewing beyond this distance a larger-aperture, higher-magnification telescope must be used. To meet this need, a $21\frac{1}{2}$ -power instrument having an aperture of 120 mm and a field of view of $2\frac{1}{4}^\circ$, was designed and a number were constructed by the Optical Shop of the Naval Gun Factory. It combines the objective lens of the US Navy Mark-I ship's binoculars with the prism and eye-piece unit of the M-17 elbow telescope. It has a special reticle (shown in Fig. 5) to assist in establishing time and position for the observation. The crosshair is illuminated by a controllable red light that does not impair the viewer's adaptation to darkness.

In use, the telescope is aimed so that the central circle is on the meridian at the desired zenith angle. Because the simulator experiments had shown that an observer rarely detected a faint object until it approached the center of the field of view, the crosshair is parallel to the meridian, but offset 0.4° in the direction of satellite travel. This allows the observer more time to signal the satellite's transit over the crosshair. The crosshair is divided into $\frac{1}{4}^\circ$ segments, allowing moderately accurate estimates of zenith angle.

Since the $21\frac{1}{2}$ -power telescope has 2.7 times the aperture diameter of the M-17, it makes equally visible a satellite 2.7² times

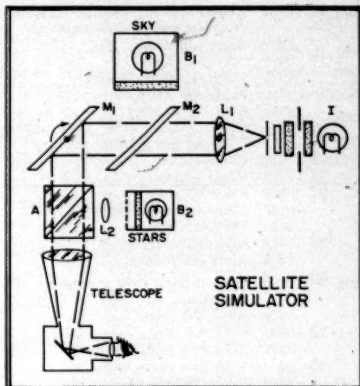


Fig. 4. Satellite Simulator. The observer, looking through an elbow telescope of the type used in the Moonwatch program, sees a star field produced by pinholes in a plate; light from lamp B₂ passes through the pinholes and lens L₂ and is reflected in by a beam splitter, A. The observer also sees a uniform twilight sky produced by light from lamp B₁ reflected in by beam-splitting mirror M₁. The satellite image is produced by a small pinhole on the focus of lens L₁; it is illuminated and its magnitude controlled by the system I. The satellite image is moved by rotating mirror M₁ at the desired speed.

fainter. This corresponds to an object 2.7 times farther away. However, this is the same amount by which the $21\frac{1}{2}$ -power field is narrower than that of the M-17. Therefore, the $21\frac{1}{2}$ -power telescope affords about the same lateral coverage in miles as the M-17 does for a satellite 2.7 times closer.

The instruments may be used interchangeably on the mounting, which consists of an adjustable bracket attached to the top of a rigid $2\frac{1}{2}$ -in pipe set in concrete. Azimuth is set by rotation of the bracket on the vertical pipe. The mounting head provides for adjustment to the plane of the meridian and for elevation. An instrument can be quickly removed when the locking screws on either side of the mounting are loosened.

Locations of Stations

Two groups of stations are used in the apogee Moonwatch network. The first group is in South Africa, where skies are usually very clear. Under the direction of C. G. Hide, secretary of the South African National Council for the IGY, and David S. Evans, South African Moonwatch coordinator, stations have been located in Cape-town, Bloemfontein, Johannesburg, and Pretoria. Observers at these stations may see the second pass of a US satellite as well as the first.

The South African stations are located so that their considerable north-south separation provides a wide observation fan for coverage of all predicted satellite orbits. These stations are so situated that for four months of the South African summer, satellites are sunlit all night over some part of the fan.

The second group of stations is arranged in a network in the United States. Good

sky conditions over a large area could be found only in the Southwest; hence, apogee stations were established at Kirtland Air Force Base, Albuquerque, New Mexico; Holloman Air Force Base, Alamogordo, New Mexico; Naval Ordnance Test Station, Inyokern, California; and Vincent Air Force Base, Yuma, Arizona.

The Albuquerque and Alamogordo stations are roughly on a north-south line, while Inyokern and Yuma form a similar pair farther to the west. The east-west separation of the pairs produces a difference in sunset times of about 40 min; thus, one pair or the other will be in a favorable position for a twilight passage of a new satellite. Also, the northern stations are located near 35°N latitude, and can, therefore, observe satellites in orbits inclined more than 35° to the equator. To the south, coverage extends well below the Mexican border, as the Yuma and Alamogordo stations are able to detect a 21-in sphere 2000 mi high passing over a point as much as 1000 mi south of them.

Observing Techniques

A fully-instrumented US apogee station has 37 telescope mounts, 37 eight-power telescopes, and the same number of 21½-power instruments. Both types of telescopes can be used on the same mounts. The 8-power telescopes are set with their fields of view centered 2½° apart along the meridian, down to 45° on either side of the zenith. As the field of each instrument is 6°, two observers, sometimes three, should see a satellite simultaneously. This minimizes the chance of a false report and increases the probability of detecting an actual satellite passage. In the high-power array, the 21½-power instruments are pointed 1° apart, so that their 2¼° fields overlap considerably.

In looking for a satellite whose position is completely unknown, the plan for the US apogee stations during evening twilight is first to use the 8-power telescopes, begin-

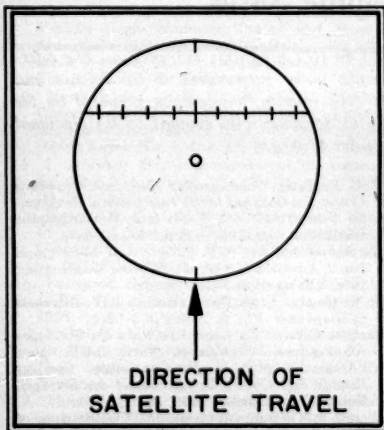


Fig. 5. Reticle of High-Power Apogee Moonwatch Telescope. Offset crosshair gives observer more time to signal satellite's transit across it.

ning when the sun is 5° below the horizon and the sky is dark enough to see a bright, low object. The wide fields of the 8-power instruments give extended coverage along the meridian needed for low satellites.

Each station will watch for about an hour, the western pair beginning about 40 min after the eastern pair; the total observing time is, therefore, about 100 min. This is roughly long enough for a satellite to travel from the eastern stations around the earth to the western stations, where a low satellite would still be sunlit. For longer revolution periods, the observing time may be lengthened by special techniques, such as tilting the meridian array in the direction of the sun for part of the time.

If the satellite is not detected by either pair of stations, it will be assumed to be too high for the 8-power telescopes, and $21\frac{1}{2}$ -power instruments will be placed on the

mounts instead. By this time the sky will have reached its full nighttime darkness, but there would be at least 100 min during which a high satellite could be sunlit while within viewing range of some part of the network. For observing during morning twilight the plan would be reversed, with low-power instruments replacing the $21\frac{1}{2}$ -power instruments as the sky changes from full night to twilight.

Experience has shown that failure of radio transmitters upon launching is one of the less likely hazards connected with satellites; however, visual observations have made it possible to determine orbits for objects that have not carried radios, such as final stages of launching vehicles. Because the apogee stations are especially well-equipped to detect faint satellites, they have already contributed valuable reports on 1958 Alpha, Beta, and Gamma.

IGY Bibliographic Notes

This is the sixth of a series of bibliographic notes on IGY programs and findings. The references are selected largely from an IGY bibliography under preparation in the Science and Technology Division of the Library of Congress. (An interim bibliography prepared by the Library and published by the National Academy of Sciences, with support by the National Science Foundation, is available from the Academy for \$1.00.)

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IGY DATA CENTER A REPORT SERIES

Three series of reports covering data obtained in the US-IGY program have been made available by IGY Data Center A; the reports, which may be obtained from the National Academy of Sciences, are listed below:

General Series:

1. "Description of the Antarctic Circulation Observed From April to November 1957 at the IGY Weather Central Little America Station."

2. "Preliminary Report of Expedition Downwind, University of California, Scripps Institution of Oceanography IGY Cruise to the Southeast Pacific."

3. "Preliminary Reports on the IGY Pendulum, Gravimeter and Seismological Programs at the University of Wisconsin."

Satellite Series:

1. "Processed Observational Data for USSR Satellites 1957 Alpha and 1957 Beta."

2. "Status Reports on Optical Observations of Satellites 1958 Alpha and 1958 Beta."

3. "Some Preliminary Reports of Experiments in Satellites 1958 Alpha and 1958 Gamma."

4. "Observational Information on Artificial Earth Satellites."

5. "Radio Observations of Soviet Satellites 1957 Alpha 2 and 1957 Beta 1."

6. "Reports and Analyses of Satellite Observations."

Rocket Series:

1. "Experimental Results of the U. S. Rocket Program for the International Geophysical Year to 1 July 1958."

Each report is priced at \$1.00, postage prepaid. Orders should be addressed to the Publications Office, National Academy of Sciences, Washington 25, D. C. Remittances must accompany orders of one dollar or less; UNESCO book coupons are accepted. Checks and money orders should be payable to the National Academy of Sciences.

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IGY BULLETIN

A monthly survey by the U. S. National Committee for the International Geophysical Year. Established by and part of the National Academy of Sciences, the Committee is responsible for the U. S. International Geophysical Year Program in which several hundred American scientists are participating and many public and private institutions are cooperating.

Status of Special Studies in Meteorology

The following report is based on material supplied by Sigmund Fritz, Lester Hubert, P. A. Humphrey, R. J. List, T. W. Machta, T. H. McDonald and W. B. Moreland, US Weather Bureau; C. D. Keeling, Scripps Institution of Oceanography; R. G. Leahy, Woods Hole Oceanographic Institution; and E. R. Ibert and D. W. Hood, Texas A&M College.

The IGY prompted an increase in the US Weather Bureau's extensive program of standard meteorological measurements of temperature, pressure, wind speed and direction, precipitation, etc. In addition, the US Weather Bureau also conducted a series of special meteorological studies during the IGY. These dealt with incoming and reflected solar radiation; ozone, CO₂, and other atmospheric constituents; nuclear "tracer" materials in the air; and aerial meteorological reconnaissance in tropical regions.

This report summarizes the aims and some of the findings to date of these investigations.

Solar Radiation

The geographically uneven absorption by the earth and its atmosphere of radiative energy is a major cause of the general atmospheric circulation. From the tropics to the middle latitudes, more solar radiation is absorbed than is lost by re-radiation; poleward from these latitudes more radia-

tion is lost than received. The resulting net warming in the tropics and net cooling in polar regions motivates the global circulation.

Our knowledge of solar energy, absorption and re-radiation, and of radiation exchanges in the atmosphere, has been quite limited. In general, visible and short-wave solar radiation penetrates the atmosphere to the earth's surface, where it is absorbed and radiated again in long waves, mainly in the infrared region of the spectrum. Water vapor, CO₂, and ozone in the air absorb most of the out-going infrared radiation and return it once again to the earth. As part of the IGY program, the US Weather Bureau measured solar radiation and long-wave radiation at six stations in Antarctica and on two drifting ice stations in the Arctic Ocean. The Wilkes Station in Antarctica also had a sub-station on the inland ice 50 mi to the east-southeast at an elevation of about 3700 ft. Similar measurements were taken at a newly-established observatory 11,150 ft above sea level, at Mauna Loa, Hawaii (19° N, 155° W).

The elements measured were the intensity of total solar and sky radiation on a horizontal surface, intensity of the direct solar beam, natural illumination, albedo, or reflectivity, of the earth's surface, hemispherical radiation (from above), and net radiation (incoming minus outgoing). The solar beam appears to be depleted to a much

smaller extent in the Antarctic and at Mauna Loa, where the atmosphere is purer, than at the two continental United States stations.

Studies at Drifting Station Alpha in the Arctic Ocean (see *Bulletin No. 12*) indicate the great importance of long-wave radiation from the overcast sky in the melting of snow and ice. During the melt season, melting proceeds much more rapidly under the overcast than it does with clear skies and bright sunshine; with clear summer skies, in fact, refreezing may occur.

Ozone

The ozone concentration in the earth's atmosphere increases vertically, reaching a maximum in a layer which may lie between heights of about 12 and 22 mi, depending on time and latitude. The amount of ozone in any vertical column in the atmosphere varies with changes in the atmospheric circulation. Hence, measurements of the distribution and variations of ozone at the surface and in the lower levels of the atmosphere provide clues to the vertical and horizontal motions of the lower stratosphere. Moreover, ozone is thought to be responsible for the large annual temperature variation in the stratosphere above the polar regions.

Ozone measurements were made by the Weather Bureau during the IGY at stations in the continental United States, in the Arctic and Antarctic, and in Hawaii. Prior to the IGY, ozone measurements for the Antarctic were completely lacking.

Surface Ozone at Mauna Loa, Hawaii: Continuous recordings of surface ozone at the Weather Bureau's Mauna Loa Observatory have been made since August 1957 with automatic chemical sampling equipment developed by V. H. Regener at the University of New Mexico.

The first 14 months' records indicate that the variations in surface ozone at Mauna Loa are related to both local and large-scale features of the atmospheric circulation.

A marked seasonal variation is evident, with a spring maximum and an autumn minimum of surface and total ozone similar to those found elsewhere. Monthly means ranged from 33 micrograms/m³ in October 1957 to 68 in April 1958, the rise being especially steep from late winter to early spring. The lowest mean hourly value observed was about 20 micrograms/m³ and the highest near 100.

Superimposed upon these seasonal trends, and often of comparable amplitude, is a pronounced daily variation, with morning maxima (a secondary peak is common shortly after sunrise) and mid-afternoon minima (see Fig. 1). This is attributed to

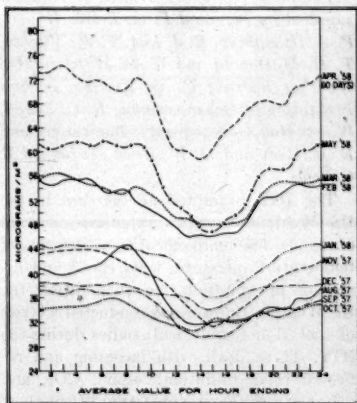


Fig. 1. Daily Variation of Surface Ozone Values at Mauna Loa Observatory.

the local circulation of up- and down-slope winds generated by the radiational heating and cooling of the mountain itself. As heated air rises in the middle of the day, the ozone is depleted by contact with vegetation, water droplets, or aerosols (suspensions in the air of fine solid or liquid particles) in the moist sub-inversion layer (below about 6500 ft).

Striking variations in the amount of surface ozone have also been observed to ac-

company changes in the broad circulation patterns of the Pacific area. Ozone increased abruptly with the transition from the prevailing trade-wind regime to a strong westerly flow around deep cyclones centered north of the Hawaiian Islands; it decreased again with the return of the trade winds.

Total Ozone at Mauna Loa: The Observatory's Dobson spectrophotometer was put into operation on November 27, 1957. This instrument determines depth of atmospheric ozone from the differential absorption by ozone of two spectral lines in the ultraviolet portion of the solar beam. The elevation of this particular instrument (the highest permanent installation of its kind in the world) and the clarity of the overlying atmosphere make its observations especially valuable for calibration purposes, principally in estimating solar radiation intensities outside the atmosphere.

Day-to-day variations in total ozone at Mauna Loa appear to be small; however, the actual amounts of ozone and the amplitude of the seasonal variation are high for that latitude. The amount varied from 250 cm in February 1958 to 288 in May. (Total ozone is measured in terms of the total thickness of ozone computed for an atmospheric column compressed to sea-level pressure.) These values, as well as the observation of a seasonal peak later than that in middle and high latitudes, require further confirmation.

Surface Ozone at IGY Little America Station, Antarctica: Surface observations

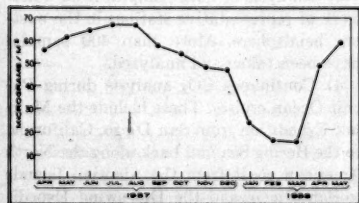


Fig. 2. Mean Monthly Surface Ozone Values at IGY Little America Station.

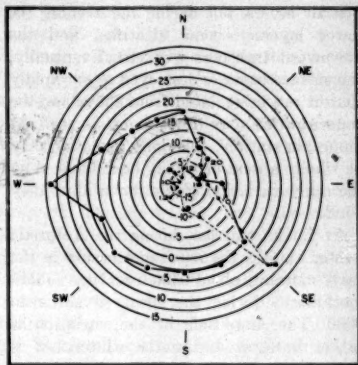


Fig. 3. Surface Ozone and Wind Roses for IGY Little America Station, June 1957. Dashed line and lighter circles represent wind-direction frequency in percent of total time; solid line and heavier circles represent surface ozone in percent deviation from monthly average of 64 micrograms/m³ of air. Winds were calm 5.4% of the time, during which surface ozone deviated $\pm 9.6\%$.

at Little America Station (78°S , 162°W) were made with the Regener chemical surface-ozone recorder. A marked feature of the annual variation (Fig. 2) is the rapid rise of ozone values in April, when the sun disappears, and the slow decrease beginning in September, after the sun returns.

The dependency of surface ozone content on wind direction is shown in Figure 3. Positive deviations from the average ozone concentration occur when the wind direction has a westerly component and negative deviations occur when it has an easterly component.

The daily variation of surface ozone concentration at Little America differs markedly from that in middle latitudes. Middle latitude stations usually report a maximum in late morning or early afternoon and a minimum in the late evening or early morning, believed to result from change in the vertical mixing caused by turbulence. In the afternoon, convective activity permits the ozone to be carried down from the up-

per air layers, but during the evening the lower layers become stratified and the downward transport weakens. Eventually, the surface ozone is destroyed more rapidly than it can be replaced from above and the concentration may drop almost to zero. At mountain stations, this daily variation may be wholly absent or it may be influenced by the daily variation of the mountain-valley wind.

At Little America during the Antarctic winter months the maximum occurs in the early morning, about 0300 local time (165th meridian); during the spring it shifts to 0600. The amplitude of the variation is rather uniform during the winter but is three times greater in September; it decreases again in the spring. (See Table 1.)

TABLE 1
Harmonic Analysis of Daily Variations in Ozone Concentration at Little America during 1957

Month	Amplitude* (Micrograms/m ³)	Time of Maximum Departure (hours after midnight)
April	2.7	2.0
May	0.6	2.1
June	2.2	2.6
July	2.0	2.9
August	1.9	2.7
September	6.1	2.9
October	2.6	4.0
November	1.2	5.5

*Average value of maximum daily departure from monthly mean value

Total Ozone at Little America Station: Observations of total ozone at Little America (Fig. 4) indicate that two maxima may occur—one during the winter and the other in late spring. The winter maximum must be confirmed by additional observations. The rise of total ozone toward the winter maximum begins one month later than that for surface ozone.

Carbon Dioxide

Air temperatures in the lower levels of the earth's atmosphere may be controlled to a large extent by the amount and distribution of CO₂ in the atmosphere, for CO₂

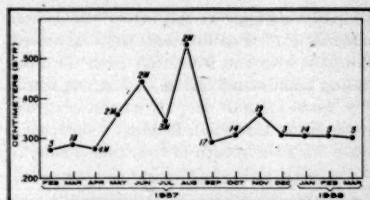


Fig. 4. Mean Monthly Total Ozone Values at IGY Little America Station under Standard Temperature and Pressure Conditions (STP). M refers to observations at full moon; all others made in direct sun. (Values are tentative, subject to further calibration of the spectrophotometer.)

absorbs much of the energy radiated outward from the earth and radiates it back to the surface. The IGY CO₂ program has attempted to determine the present amount and distribution of CO₂ in the atmosphere, as well as any evidence of long-run changes.

Scripps Institution of Oceanography Program: Scripps Institution of Oceanography, which had major responsibility for IGY CO₂ analysis, employed the following four methods of investigation:

- 1) Continuous analysis of CO₂ concentrations at points where local (industrial) influence is minimal—Little America Station, Mauna Loa Observatory, and Scripps' own location, La Jolla, California.
- 2) Analysis of flask samples taken at the 500-mb level (about 18,000 ft) over the Pacific Ocean on US Air Force Weather Service reconnaissance flights. Eighty-four samples were taken on seven flights.
- 3) Analysis of flask samples from a network of representative stations in the western hemisphere. More than 400 samples have been taken and analyzed.
- 4) Continuous CO₂ analysis during Pacific Ocean cruises. These include the Mulkuk Expedition from San Diego, California, to the Bering Sea and back along the North American coast from the Aleutian Islands to San Diego, and the Downwind Expedition, from San Diego to Tahiti and to Valparaiso, Chile (see *Bulletin No. 7*).

The program was made possible by the availability of a new, non-dispersive infrared gas analyzer with a precision of ± 0.2 parts per million of CO_2 in normal air for most applications. Three of these instruments, at Mauna Loa, Little America, and La Jolla, are adapted for continuous air stream analysis. An additional instrument at the Scripps laboratory has been adapted for analyzing up to six flask samples an hour.

Over the Pacific Ocean, at Little America, at Mauna Loa, at Scripps Institution, and at several stations in the northern hemisphere where numerous flask samples have been collected, the CO_2 concentration appears to be nearly the same.

Continuous measurements at Little America show the smallest variations, about $\pm 0.3\%$. Mauna Loa shows a slightly larger variability, about $\pm 1.0\%$, and measurements during the two ocean cruises

show a variation of $\pm 2.0\%$. The small degree of variability for these areas is in striking contrast to current atmospheric CO_2 measurements in Scandinavia, where a range between 250 and 400 ppm, or a variation of about 60%, is reported (see Figs. 5 and 6).

Woods Hole Oceanographic Institution Program: During August 1958, a series of 14 vertical soundings were made off the coast of Massachusetts with a CO_2 analyzer installed in the Institution's aircraft. The measurements were made east of Nantucket Island and, when weather permitted, over the Texas Tower on Nantucket Shoals. Routine meteorological observations were carried out in conjunction with the CO_2 measurements, which were taken at altitudes ranging from 100 to 10,000 ft.

The soundings indicated marked varia-



Fig. 5. Average Index Values of Atmospheric CO_2 —Spring.

Note: The index values are based on a preliminary calibration; however, variability assessment depends upon comparative values rather than upon calibration.

Stations as follows: LA—Little America; ML—Mauna Loa Observatory; LJ—La Jolla; A—Drifting Station Alpha; CH—Cape Hatteras; L—Lark India flights; P—Ptarmigan flight; S—Stork flight; SP—South Pole.

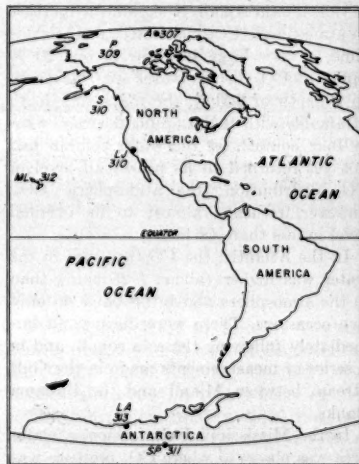


Fig. 6. Average Index Values of Atmospheric CO_2 —Late Summer and Fall.

tions of CO_2 content with altitude, as previously noted in other areas. At Nantucket, an average difference of 10 ppm was found from top to bottom of the profile, and larger variations were common. A CO_2 minimum was often noted between heights of 1000 and 3000 ft.

No correlation has as yet been found between CO_2 values and the various factors of air-mass identification, such as mixing ratio. However, the persistence of a given vertical CO_2 pattern over a period of three or four days was noted when meteorological conditions in the area were similarly persistent.

Texas Agricultural and Mechanical College Program: On the IGY cruise of the Texas A & M research vessel *Hidalgo*, continuous measurements of atmospheric and oceanic CO_2 pressures, particularly near the sea-air interface, were taken. An interesting series of observations was made during a violent rain squall. A significant increase in atmospheric CO_2 was noted; at the same time, a very large increase (about 20–50 ppm) of CO_2 in the water was measured to a depth of 200 ft, the maximum depth attainable with the sampling device. Twenty-four hours later the water column had not yet returned to its pre-squall level of CO_2 distribution; the atmospheric CO_2 , however, returned almost to its original level in less than six hours.

In the Atlantic, the CO_2 pressure in the water was higher (about 1–25 ppm) than in the atmosphere above the water on only two occasions. These were during and immediately following the rain squall, and in a series of measurements made in the Gulf Stream between Miami and the Bahama Banks.

In the Mississippi Delta region, a water area was observed where CO_2 pressure was greater than 1000 ppm. In the atmosphere just above, a decrease in the CO_2 pressure was detected between air samples taken at 2 in and at 25 ft above the surface. These conditions, encountered when the ship was cruising downstream at 10 knots, persisted

for about one hour. Both upstream and downstream from that area, conditions were more nearly normal for rivers: i.e., while the water had a higher CO_2 pressure than did the open Gulf or the Atlantic, it had a lower pressure than the air above it.

Nuclear Radiation

The Naval Research Laboratory conducted a program of daily air-filter collections at 20 stations along the 80°W meridian from Thule, Greenland, to Punta Arenas, Chile, in cooperation with the Weather Bureau and the meteorological services of several other nations. (See *Bulletin No. 14* for background on other phases of the IGY nuclear radiation program.)

Very little fission-product radioactivity was found south of the equator (see Fig. 7). Since most of the fission products were injected into the atmosphere in the northern hemisphere, the negative finding suggests that the exchange of air between the northern and southern hemispheres may be slow.

Apparently, radioactive decay, gravitational settling, and "scavenging" by precipitation removed most of the radioactive particles from the air before significant inter-hemispheric exchange could occur.

Aircraft Weather Reconnaissance in Tropical Areas

Weather data along two tropical flight paths were obtained by US Air Force planes during several World Meteorological Inter-

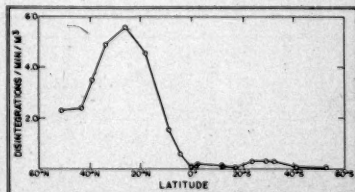


Fig. 7. Average Fission-Product Concentration in the Atmosphere During February 1968 Along the 80°W Meridian. Profiles for other months show a similar trend.

vals (IGY-designated 10-day periods including either a solstice or an equinox).

Twenty flights, two per day, were made between Puerto Rico and North Africa during the period March 16-27, 1958, partly at 6000 ft and partly at 20,000 ft. A total of 16 dropsondes (soundings of temperature, pressure, and humidity telemetered by instruments parachuted from the aircraft) were made along the route.

A more southerly "Special Tropical Track," from Puerto Rico to about 33°W, 13°N and return, also was followed. Four

flights at 10,000 ft were made on September 18 and 26 and December 12 and 18, 1957. On each flight, 13 dropsondes were made.

An important unknown of the tropical atmosphere has been the height of the trade-wind moist layer. Graphs of the horizontal variation of the moist layer, based on data obtained in the tropical weather reconnaissance program, are being studied in relation to perturbations in easterly trade winds, some of which develop into hurricanes.

Rocket Studies of the Arctic Ionosphere

The following material was supplied by J. C. Seddon and J. E. Jackson, US Naval Research Laboratory, Washington, D. C.

Man's activities in Arctic regions, and even his safety, depend to a large extent upon reliable radio communications. Information obtained in the past indicates that the Arctic ionosphere (the electrically-charged, radio-wave reflecting layer of the upper atmosphere) is extremely variable, especially in the auroral zone, the region of maximum auroral frequency. Radio-wave absorption, at times very high in this zone, is almost unpredictable. Occasionally, absorption becomes so severe that long-range radio communication is impossible on any frequency. This condition is called a "polar radio blackout."

Ionosphere records obtained by the standard radio-sounding methods from the ground are usually blank during a blackout because of the high absorption. Rocket-borne instruments, however, can send signals down to the ground through this absorbing blanket, supplying information on the absorption and on electron densities at different altitudes; thus, such rocket experiments may supply clues for development of communications procedures to circumvent the effects of a blackout.

The first measurements of electron density ever made during a polar blackout were obtained by two of the rockets launched under the IGY program at Fort Churchill, Canada, in the auroral zone. The launchings were conducted by the US Naval Research Laboratory. One rocket penetrated the E-region of the ionosphere during a blackout. (The E-region, from heights of about 90 to 130 km, reflects medium-frequency radio waves.) Two other rockets reported on here reached altitudes of 235 km, well into the F-region, which reflects high-frequency radio waves. One of these was launched during a blackout.

Method of Observation

The method used to measure electron density was the same as that employed at the White Sands Proving Ground, New Mexico, since 1946. A rocket carrying two radio transmitters that radiate two unmodulated signals is fired nearly vertically. One signal has a frequency of 7.75 mc; the other is six times higher and the ionosphere has essentially no effect on it. This higher frequency, therefore, serves as a reference frequency.

Both frequencies experience a Doppler shift, a seeming shift in frequency which

occurs when a transmitter is moving toward or away from the receiver. This shift is observed at the ground as a decrease in frequency on the up leg of the rocket flight and as an increase on the down leg; however, the lower frequency is shifted a different percentage when the rocket is in the ionosphere than when it is beneath the ionosphere.

Ground stations located near the launcher at Fort Churchill receive the two frequencies. After the 7.75-mc signal is multiplied by a factor of six, the signals are compared. The difference is then used to compute the index of refraction (the ratio of the signal velocity in the medium to its velocity in a vacuum). The electron density required for this index of refraction can then be derived.

Results

Electron density profiles for the three flights are shown in Figure 9. Profiles A and B show electron densities and differential absorption during polar blackouts; pro-

file C shows the electron density for a winter midnight without a blackout. (Differential absorption is the difference in absorption across a given region of the ionosphere experienced by the two components of a radio wave, ordinary and extraordinary, as they travel through it. The components are analogous to the similar components of light traveling through a doubly-refracting medium.)

Profiles A and B indicate an unusually high electron density in the D-region during the polar blackouts, mainly between 58 and 78 km. The curves show very few abnormalities for the E- and F-regions. For the region above 130 km, the curves are extremely smooth, indicating that the ionosphere was stable and free of irregularities in spite of the blackouts. Differential absorption during the polar blackouts, as shown on graphs A and B, reached a maximum at about 67 km.

Profile C shows the very low D- and E-region electron densities characteristic of

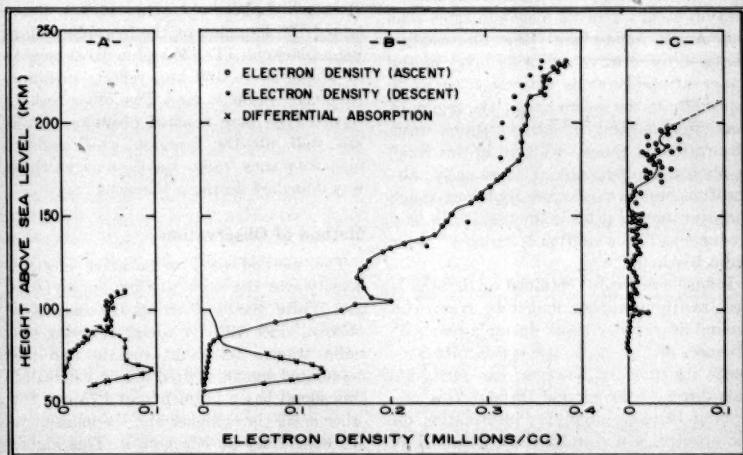


Fig. 9. Profiles of Electron Density and of Differential Absorption at 7.75 mc over Fort Churchill. Profile A is based on a rocket flight at 1332 CST, Nov. 15, 1966; B on a flight at 1216 CST, Jul. 4, 1967; and C at 0017 CST, Feb. 4, 1968. Curves B and C represent extreme conditions: summer noon and winter midnight.

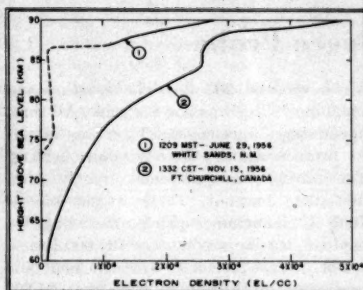


Fig. 10. D-Region Electron-Density Profiles at Fort Churchill During a Radio Blackout and at White Sands Proving Ground, New Mexico, on a Day of Above-Normal Absorption. Dashed portion of curve 1 based on fewer data points, using Faraday rotation technique.

the long absence of the sun's radiation. The E-layer was thin, with a maximum electron density of only $20,000/\text{cm}^3$. The bottom of the F-region is evident on graph C at about 165 km.

Figure 10 compares one of the Fort Churchill profiles with a profile obtained at White Sands on a day of above-normal absorption. From the indices of refraction and the differential absorption it is possible to calculate the frequency of collisions between electrons and neutral particles, assuming an ion density of less than $10^7/\text{cm}^3$. The values obtained are surprisingly low for all flights, both summer and winter.

Magnetograms (records of the strength of the earth's magnetic field at the surface) show an abrupt decrease in the horizontal component of the magnetic field at Fort Churchill a few minutes before the launching on July 4, 1957; the decrease lasted until well after the flight. Magnetograms and ionograms obtained at this time at lower latitudes show little or no effect, indicating that the ionospheric disturbance observed was a polar blackout only.

The three rocket flights, though not pro-

viding enough data to form final conclusions, did furnish very strong evidence that a polar blackout is due to an abnormal number of free electrons in the D-region of the ionosphere, and that moving electric charges play an important role in this phenomenon. The polar blackout seems to involve little change in the E- and F-regions of the daytime ionosphere. In addition, the daytime electron density in this region of the ionosphere is similar to that observed in lower latitudes. Further, it appears that the electron collision frequency with neutral particles may be $\frac{1}{3}$ or $\frac{1}{4}$ that previously estimated.

It was also found that radio-wave absorption in the Arctic ionosphere varies from extremely high to extremely low values.

Additional Investigations

The data discussed in this report were obtained under a limited variety of ionospheric conditions. Hence, the scope of the program originally planned has been extended to accumulate further data.

Three additional rockets instrumented for ionospheric research were launched from Fort Churchill during November and December 1958. The data obtained are being reduced and analyzed. The first of the three, using an Aerobee-Hi, was a very successful nighttime launching directly into the center of an aurora. This was the first time electron density measurements were made in an aurora.

The remaining two launchings were attempts to obtain data above the level of maximum electron density of the F2-region (about 300 km). A new rocket, the Spacrobe, designed to reach heights in excess of 400 km carrying a newly-designed, lighter ionosphere payload, was used. The rockets attained heights of only about 100 and 200 km, but it is hoped that further efforts with this rocket-payload combination will provide the desired data.

Second IGY Space Probe

At 12:45 am EST, December 6, 1958, the fourth in a series of five US-IGY space probes, and the second to reach a substantial distance from the surface of the earth, was launched from Cape Canaveral, Florida. The probe was named Pioneer III. The launching was accomplished under management direction of the National Aeronautics and Space Administration by the Army Ballistic Missile Agency and the Jet Propulsion Laboratory of the California Institute of Technology.

Launching: The launching vehicle, a Juno II rocket system, had four stages and was 76 ft long overall. The first stage was a modified Jupiter rocket weighing approximately 120,000 lbs. The three high-speed upper stages consisted of 15 scaled-down solid-propellant Sergeant rockets developed by JPL. The second stage, weighing 721 lbs, consisted of an annular cluster of eleven of these Sergeants. Three Sergeants in a concentric cluster made up the third stage,

which weighed 207 lbs. The fourth stage, weighing 59 lbs, was one Sergeant. All three upper stages were covered by a nose fairing to protect against aerodynamic heating. The fairing was jettisoned shortly after first-stage burnout. Total weight of the Juno II launching vehicle, including the payload, was approximately 121,000 lbs.

The designed velocity after burnout and separation of the fourth stage was 24,897 mph. However, because the first stage burned out approximately 3.7 sec early, the velocity attained was about 24,000 mph. Although Pioneer III did not reach its maximum objective—the environs of the moon and beyond to a heliocentric orbit—it did reach an altitude of about 63,000 statute miles.

Instrumentation: The cone-shaped, gold-plated Pioneer III payload (Fig. 11), 23 in long and 10 in wide at maximum diameter, was mounted atop the fourth stage. It contained a small radio transmitter; two

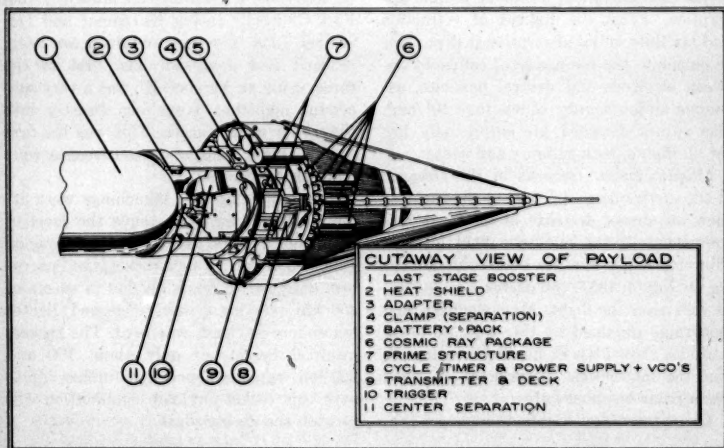


Fig. 11. Pioneer III Space Probe. Adapted from US Army photograph.

Geiger-Mueller counters to measure radiation in space; a photoelectric sensor to receive reflected light from the moon; and a de-spin device to slow the pay-load down as it neared the moon. The transmitter weighed 1.1 lbs, operated on a frequency of 960.05 megacycles with a power level of 180 milliwatts, and was powered by chemical batteries.

The radiation experiment carried in Pioneer III was designed by James A. Van Allen and his staff at the State University of Iowa and was engineered by JPL scientists. Van Allen and an undergraduate student assistant, Louis Frank, calibrated the radiation detectors and conducted the final pre-flight radiation calibration at the SUI physics laboratories.

Tracking: Two major stations tracked Pioneer III: a JPL tracking station at Mayaguez, Puerto Rico, and an 85-ft antenna at JPL's Goldstone Tracking Station on the California desert near Barstow.

Pioneer III re-entered the atmosphere over French Equatorial Africa, and presumably disintegrated, at 2:51 pm EST, December 7, 1958.

Preliminary Results

The data provided by Pioneer III during

its 38-hour flight proved particularly valuable. It now appears that there are two radiation belts: the first is found roughly between 1400 and 3400 mi from the earth's surface, the second between 8000 and 12,000 mi.

Each of these two belts was found by Van Allen and his staff to have a very high intensity of charged particles, reaching a peak about 2400 mi out in the first belt and about 10,000 mi out in the second; a high of 25,600 counts/sec was registered. These high counts are equal to about 10 roentgens/hr, if electrons, or about 100 roentgens per hour, if protons. However, Van Allen believes it is still too early to offer a definite appraisal of whether the more penetrating component of the radiation consists of electrons or protons.

From the point of view of space travel, it remains to be seen whether acceptable means of dealing with the problem can be found. The maximum safe weekly dosage has been recommended to be no more than three-tenths of one roentgen. Between the two belts, the radiation level got no lower than three-tenths of one roentgen per hour. However, the area between the lower Van Allen radiation belt and the earth would appear to be safe for travellers for extended periods of time.

Second Conference on Ionosphere Studies Using Earth Satellites

The second conference on "Studies of the Ionosphere Using Radio Observations of Earth Satellites" was held on September 29, 1958, at the Central Radio Propagation Laboratory (CRPL) of the National Bureau of Standards (NBS) at Boulder, Colorado. (The first conference, on November 5, 1957, was reviewed in *Bulletin No. 7*.)

Organized by the USNC-IGY under the direction of A. H. Shapley, the conference provided a forum for reports on methods,

techniques, and results of ionospheric experiments based on radio signals from artificial satellites. More than 50 scientists representing 16 participating institutions attended the one-day symposium, including the Ionospheric Committee of the newly-created Space Science Board of the National Academy of Sciences.

Summary reports of types of studies now being undertaken were presented by representatives of each institution. These studies

are indicated in Table 2. All experimenters are continuing the collection and analysis of data. Stanford University reported two items in process of publication. Some difficulty in data reduction has developed owing to the lack of sufficiently precise ephemerides.

Summary of Reports

—Robert Jastrow, Naval Research Laboratory, discussed a Soviet paper presented at the 5th CSAGI Assembly, in Moscow, August 1958. The Soviet paper reviewed electron-density determinations based on

signals from 1957 Alpha 2 (Sputnik I) and the measurement of ion density using signals from 1958 Delta 2 (Sputnik III).

An analysis based on the times of radio dawn (the instant the signal is heard) and radio set (the instant it disappears) gave a surprisingly great scale height of 300 ± 100 km as deduced from an assumed exponential decrease of electron density above the F2-layer maximum. (Scale height is the hypothetical additional extent of the atmosphere above a given reference level if the total additional atmosphere is assumed to be of homogeneous density equal to that of the

TABLE 2
Ionospheric Studies Using Satellite Signals

Agency	US-IGY Satellites	Sputnik III	Sputnik I & II (Analysis)
Nat. Bur. Standards, Boulder, Colo.		D R P S	R
U. of Wash.	S	S	
Stanford U.		D P S A	D P A
Penn. State U.		D P S	Beginning
U. of Ill.	P S SS	P S SS	S PA (Sput. I)
Geophys. Inst., U. of Alaska		D P S	M
Geophys. Res. Directorate		Pr	OD
Linfield Res. Inst.		D R P S SS	
Cornell U.		S	SA
High Altitude Observatory			D P S
Lincoln Lab.		P	D R
Army Ballistic Missile Agency	D S		
Ballistic Research Lab.	D	D	
Army Signal Research and Development Lab.	D P	D P	D P

Experimental Code:

A: Antipodal
D: Doppler
M: Multi-Station
OD: Orbital Data

P: Polarisation
PA: Propagation Anomalies
Pr: Propagation

R: Refraction
S: Scintillation
SA: Spin Analysis
SS: Signal Strength

reference level; scale height is directly proportional to the molecular temperature at the reference level.) The integrated (per column of unit area) number of electrons above the F2 maximum was found to be 3.5 times that below. Rough estimates of the neutral-particle density, based on reasonable assumptions of the value of the recombination rate, fall exactly in the middle of a model atmosphere proposed by Jastrow and Harris for temperate latitudes at 400 km.

Ion densities of $1.8 \times 10^5/\text{cm}^3$ at 795 km and $5.2 \times 10^5/\text{cm}^3$ at 242 km were obtained from data gathered by ion traps in Sputnik III. These densities are in good agreement with those obtained with Sputnik I signals and with rocket results.

—J. W. Warrick of High Altitude Observatory (HAO), University of Colorado, Boulder, Colorado, reported on the International Astronomical Union conference, held in Moscow immediately following the CSAGI Assembly. He briefly discussed four of the Soviet papers presented. Some of their major points were as follows:

- 1a) Sputnik III measurements indicated an increase in X-ray flux above 60°N latitude.
- b) Instrumentation in Sputnik III did not detect gamma-rays during solar flares on June 6, 1958.
- 2a) During the magnetic disturbances of May 15, 1958, ions, protons, and X-rays in the 1–100 keV range were observed by instrumentation aboard Sputnik III. A low-energy electron flux on the order of $4 \times 10^4 \text{ ev/cm}^2/\text{ster}$ appears to be the most likely cause. (A ster, or steradian, is a unit solid angle.)
- b) Rocket flights of very-high-frequency (VHF) interferometers indicate that the F2 maximum may be 50–100 km lower than usually assumed.

Warwick also reported a value of $3.8 \times 10^{-13} \text{ gm/cc}$ for atmospheric density at perigee of Sputnik I (about 140 mi) over

Boulder from analysis of spin fading as a function of time over the life of the transmitter. Some irregularities in the curve of spin period against time are larger than the values allowed by the experimental errors. These irregularities may imply a large electrical charge in the satellite at times.

—S. J. Bauer, US Army Signal Research and Development Laboratory, reported that the rotation of the plane of polarization of radio waves (the Faraday effect) causes a characteristic type of fading of satellite signals; this can be used to determine both the integrated (up to satellite height) and local (at the satellite) ionospheric electron density if observations are made simultaneously at two or more selected locations.

—R. S. Lawrence, CRPL, NBS, Boulder, Colorado, reported on a program to determine the ionospheric effect on Doppler measurements by observing the differences in ordinary and extraordinary signal paths (see pg. 8) from satellites to a ground station. Computer programs have been developed to perform these analyses.

—B. Wieder, CRPL, NBS, Boulder, discussed observations of the systematic change with time of the Faraday fading rate using signals from 1958 Delta 2. The fading rate is slow when the satellite is to the north and increases when it is toward the south; a non-systematic fade was observed overhead. The fading rate is greater for north-south than for south-north passes. Since the satellite is higher in the sky during the north-south passes, the enhanced fading rate is apparently due to the longer ionospheric paths traveled by the signals. Nighttime passes have much slower fading rates than daytime passes.

Variations in ion concentration are indicated by differences in fading rate of as much as a factor of 3 for different satellite passes. The fading rate seems to correlate well with the square of the F2 critical frequency.

—C. G. Little, CRPL, NBS, Boulder, reported that Faraday fading times of signals

from a satellite traveling near the bottom of the F2 region increased from 1.5 to 4 sec between successive nodes, or peaks, on a pass from southwest to northeast, although many variations occurred. The lateral extent of observed irregularities in ionospheric structure was about 100 km. The integrated electron content per cm^2 column required to produce this effect was calculated as on the order of $10^9/\text{km}$.

—G. W. Swenson, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, presented a summary of the collection and analysis of 20- and 40-mc interferometer data for satellites 1957 Alpha 2 and 1957 Beta. A post mortem ephemeris for 1957 Alpha 2, based on time and longitude of passage of the 40th parallel, was prepared.

Good agreement was reported between this ephemeris and visual observations for October 1957. Transitions from "hashy" to regular fading, and vice versa, were observed when the satellite was both above and below the F2 maximum. They are apparently not correlated with sunrise or sunset. Abrupt changes in signal strength may be owing to characteristics of the propagation path, the number of hops, and the skip distance.

—O. K. Garriott, Stanford University, Stanford, California, described Doppler-Faraday reduction and work on ionospheric irregularities using Sputnik III signals. On many of the records of change of signal strength with time, the time can be identified at which the ray path between satellite and receiver became approximately perpendicular to the earth's magnetic field lines. This is shown as a marked reduction in the rate of Faraday rotation, and frequently as a change from linear to elliptical polarization. Under these conditions the difference in phase-path length between the ordinary and extraordinary rays is relatively small. The difference in path length at any time can be determined simply by counting the number of fades due to Faraday rotation

between the reference time and the time of interest. This permits estimating integrated electron density along the ray path.

An approximate equation indicates that the rate of Faraday rotation is proportional to the number of electrons per unit column below the satellite height. Reasonably good results may be obtained for satellite positions near its closest point of approach.

It was noted that a flutter effect in the signals may be owing to their arrival over different paths below the ionosphere rather than to ionospheric irregularities. Study of signals from the satellite's antipodes (at an Indian Ocean location) suggests tilt of the ionosphere at sunset, with possible confinement of the signals to a narrow cone of arrival.

—W. J. Ross, Pennsylvania State University, University Park, Pennsylvania, reported the accumulation of four months' simultaneous recordings on the 20.0045- and 40.009-mc/s transmissions of 1958 Delta 2; the recordings were made at each of three stations several hundred miles apart. Data reduction and analysis are proceeding. Doppler data are being reduced; polarization and scintillation effects are being generalized; and some observed phase-path scintillation between 20 mc/s and 40 mc/s, presumably owing to irregularities in the propagation path, is being investigated.

—T. E. Van Zandt, CRPL, NBS, Boulder, spoke on the calculation of true heights of electron-density levels based on ionization effects. Large inaccuracies were found. Unobserved low-density ionization was reported to be the primary cause of error and it was concluded that true-height values for the transition periods, about an hour after sunset and before sunrise, are especially uncertain. An improved method of calculation, expected to provide true-height values accurate to within 5-10 km, was to be put into use about January 1959.

—P. R. Arendt of the US Army Signal Research and Development Laboratory reported that the Laboratory has observed

nearly all passages of all artificial satellites coming within reach of the receiving station at Deal, New Jersey. A library of more than 4,500 recordings (on magnetic tape and on paper charts) is available. Final evaluation of the data depends on the existence of fairly precise ephemerides giving position and altitude of the satellites for time intervals of one minute or less. Only recently have such data been made available. Meanwhile, evaluation based on observations of the fading periods produced by the Faraday effect have been made. Such observations enable determination of whether the satellite moves in zones of equal or varying electron density or whether

the vehicle is in zones where no magneto-ionic effects are created.

Observations of 1958 Epsilon (Explorer IV) also indicate strong magneto-ionic effects at altitudes between 1000 and 2000 km. These findings coincide with the results of moon-echo observations made in the Signal Research and Development Laboratory which indicate that 75% of the observed Faraday rotation might be due to effects occurring on top of the F-layer maximum.

Shapley urged institutions to submit proposals and suggestions for ionospheric experiments to the Space Science Board's Committee on the Ionospheres of the Earth and Planets.

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Titled "An Interim Bibliography on the International Geophysical Year," it was prepared by the Library of Congress as a joint project of the Library, the Academy, and the National Science Foundation.

Entries were selected for scientific value,

extent of coverage, historical interest, uniqueness, and availability. English translations are given for titles in Russian, East European languages, and Japanese, and the existence of complete translations or English summaries is noted.

Orders should be addressed to the Publications Office, National Academy of Sciences, Washington 25, D. C., and accompanied by check or money order for \$1.00.

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 IGY BULLETIN

A monthly survey by the U. S. National Committee for the International Geophysical Year. Established by and part of the National Academy of Sciences, the Committee is responsible for the U. S. International Geophysical Year Program in which several hundred American scientists are participating and many public and private institutions are cooperating.

Seismic Studies in the Western Caribbean

This report is based upon material presented at the IGY Symposium of the American Association for the Advancement of Science, December 29-30, 1958, by John W. Antoine of Lamont Geological Observatory, Columbia University.

During and for several years prior to the IGY, oceanographers of the Lamont Geological Observatory made many seismic refraction measurements in the Caribbean area. Their aim was to study crustal structure in an island-arc province in order to determine its relationship to ocean-basin and continental structure. Many geologists and geophysicists feel that island arcs represent an intermediate phase in continent growth. Others hold the view that the interior basin of the island arc is a faulted continental mass.

The results discussed here are based on 38 seismic profiles, most of them reversed to check accuracy, representing the first submarine structural data in the western Caribbean (see Fig. 1). In general, the crustal thickness varies with water depth, a thin crust being associated with deep waters and a thicker, more complicated crustal section with shallower water. The crust is thinnest in the Cayman Trough, where only .5 km of sediment and 3.2 km of crustal rocks were found. In some of the shallower areas, the thickness of the crust was so great that its base could not be reached with the equipment used.

Analysis of Cross Section

Location: Figure 2 is a cross section through the crust from the Yucatan Basin south-easterly across the Cayman Ridge, the Cayman Trough, the Nicaraguan Rise, and the Colombian Basin to the Continental Slope off Cape Augusta, Colombia. The average water depth in the Yucatan Basin and in the Colombian Basin is about 4 km, while in the Cayman Trough it is about 5 km, deepening to almost 7 km in the Bartlett Deep. The section crosses the Nicaraguan Rise in a saddle between Rosalind Bank, on the west, and Pedro Bank, on the east. The average depth of water along this part of the Rise is about 1 km. The Cayman Ridge was crossed between Grand Cayman



Fig. 1. Western Caribbean, Showing Locations of Seismic Observations and of Structure Cross Section (A-A').

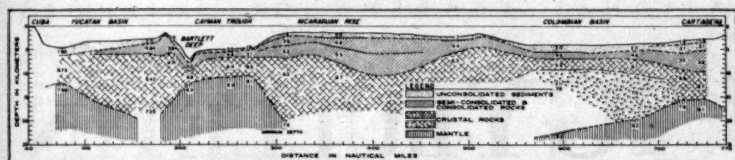


Fig. 2. Structure Cross Section of Western Caribbean from Western Cuba to the Continental Slope off Colombia. The legend represents a possible rock section.

Island and Little Cayman Island where the minimum sounding was 1.2 km.

Structure: The structure along the cross section is widely variable, as might be expected in an area of such varied physiography, including broad basins, prominent ridges, and a deep-sea trench. In general, there is good correlation between topography and crustal thickness: the crust is thin under the Cayman Trough, of intermediate thickness under the basins, and thick under the ridges. An entire crustal section, reaching to the base of the crust, was measured only in the Yucatan Basin, the Cayman Trough, and the southern part of the Colombian Basin. The depth to the mantle, the layer beneath the crust, is 10–11 km beneath the Cayman Trough and 14–15 km beneath the basins. The mantle depth under the ridges, as obtained by extrapolation and computations based on minimum possible depths for known seismic-wave velocities, is 20–25 km.

The seismic-wave velocities in the major crustal layer range from 6 to 7 km/sec, and in some places, the velocity apparently increases with depth in the layer. In the material overlying the main crustal layer, the velocity varies widely; hence, a clear division between the crust and the overlying material cannot always be drawn. The upper part of the section consists of sediment layers, some unconsolidated and others probably somewhat compacted or metamorphosed. The material above the main crustal layer is thickest on the Nicaraguan Rise, intermediate in thickness in the basins, and thinnest in the Cayman Trough.

The most prominent structural feature in

this cross section is the thin crust under the Cayman Trough, where it is thinner than the average oceanic crustal layer (4–6 km). It is also notable that the high-velocity crustal rocks are relatively thin in the Yucatan Basin and in the southern part of the Colombian Basin, the thickness in these places being about the same as the average for ocean basins. These areas of thin crustal rocks are particularly prominent because of their proximity to the very thick crustal sections beneath Cuba, the ridges, and the South American continent.

In the middle of the Colombian Basin the crustal rocks are at least twice as thick as the average oceanic crust, even though the water depth is only about 1 km less than average ocean depth. A similar condition exists in the Venezuelan Basin, where the crust was also found to be unusually thick everywhere except in the southern and central parts. Measurements in the areas where the thick crust was found showed that the velocity increases downward in the crust. This suggests that the average density of much of the crustal layer in these areas is higher than that usually assumed for the oceanic crust; hence, the thick crust may be reconciled with the moderately deep basin.

Conclusions

Most geologists and geophysicists familiar with the Caribbean area agree that it is in a state of long-range change. It is not certain, however, whether it is rising or subsiding. Structure resembling an ocean basin and structure resembling a continental mass are both found along this cross section,

within 80 mi of each other. The oceanic structure is represented by the Cayman Trough, the continental structure by the Nicaraguan Rise.

The structure under the Cayman Trough has been well determined with regard to both depth to the mantle and to the seismic-

wave velocities in the crust and mantle. The depth to the mantle under the Nicaraguan Rise has not been measured, but, on the basis of minimum depth calculations and extrapolation, it was estimated to be 20-25 km, or possibly deeper. This is almost within the range of continental structure.

Van Allen Radiation Belt

The following report is based in large part on material provided by James A. Van Allen and Louis A. Frank of the State University of Iowa.

Regions of intense radiation surrounding the earth in space were first discovered by Van Allen and his colleagues at the State University of Iowa through analysis of Geiger-counter data telemetered to earth by satellites 1958 Alpha and 1958 Gamma (Explorers I and III), as described in *Bulletin No. 13*. Special instrumentation in 1958 Epsilon (Explorer IV) extended knowledge

of the nature of the radiation and its distribution (see *Bulletin No. 15*).

Both Pioneer I and Pioneer III, the first probes to travel many earth radii into space, traversed the Van Allen radiation belt and returned through it to burn up in the earth's atmosphere (*Bulletins 18 and 20*). Pioneer III, in particular, obtained important data. This report describes present knowledge of the radiation region, with emphasis on data recorded by Pioneer III.

Working closely with Van Allen at SUI in the design of the radiation experiment

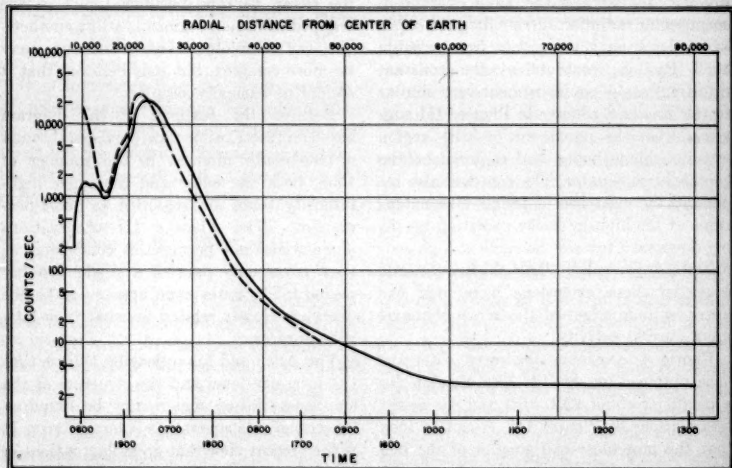


Fig. 3. Counting Rate of Geiger-Mueller Tube in Pioneer III. Solid line represents outgoing leg, dashed line return leg. Distances in km.

and in the interpretation of results were Carl E. Mcllwain and George H. Ludwig. Dan Schneiderman of the Jet Propulsion Laboratory, California Institute of Technology, supervised the engineering of the Pioneer III payload. Partial support for the SUI portion of the Pioneer III experiment and for data analysis was provided by sub-contract with JPL.

The Radiation Region

Excellent telemetry afforded continuous radiation observations to a radial distance of 107,400 km from the earth's center on the outgoing leg of the Pioneer III flight, and from 60,000 to 9400 km on the incoming leg. Figure 3 shows the true counting rate of the standard Geiger-Mueller tube carried by the probe. The data obtained by a second counter, specially designed as an "ambiguity resolver" for the first instrument, was consistent with that of the first throughout.

The counting-rate data show the existence of two distinct, widely separated, high-intensity zones within the region of trapped, corpuscular radiation surrounding the earth. In earlier studies, using data from satellite 1958 Epsilon, contours of the constant counting rate of an instrument very similar to the standard counter in Pioneer III suggested that the maximum-intensity region was doughnut-shaped and centered on the geomagnetic equator. The contours also indicated the existence of tongue-like extensions of the high-intensity radiation reaching downward toward the earth at high geomagnetic latitudes. The higher-latitude edges of these extensions were near the lower-latitude edges of the zones of maximum auroral activity.

Figure 4 combines the very extensive data obtained by satellite 1958 Epsilon (to a height of about 2200 km) and the newer observations of Pioneer III. It can be seen that the innermost and smaller of the two zones occurs within one earth radius of the surface and encircles the earth within the

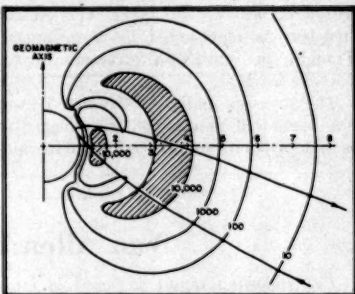


Fig. 4. Meridional Plot of Trapped-Radiation Region. Distances given in earth radii; contours represent intensity in counts/sec.

tropical and subtropical zones. A high of 16,700 counts/sec was recorded in this zone on the return leg of the Pioneer III flight. The outermost zone, extending roughly from two to three earth radii from the surface and arcing along the lines of geomagnetic force to points above the polar regions, had a peak of 25,600 counts/sec. Much of the detail of this meridional plot of the trapped radiation regions is still hypothetical; the complete intensity-structure may be more complex, but it is believed that it cannot be basically simpler.

Because the features of the diagram based on 1958 Epsilon data persisted through a two-month interval in the summer of 1958, both the outer and the inner high-intensity zones are regarded as quasi-permanent. (The Pioneer III observations alone would not permit this conclusion, as they cover only part of a single two-day period.) The outer zone appears to be the one more closely related to usual, high-latitude auroras.

Van Allen and his colleagues believe that the intensity-level and the structure of the trapped-radiation region may be found to be strongly dependent on solar activity. It is the present view that gross fluctuations in the radiation region may be expected over the eleven-year solar cycle. In detail, how-

ever, the intensity structure may fluctuate on a much shorter time scale.

Although the Pioneer III observations supply no detailed information on the penetrability characteristics of the radiation, 1958 Epsilon data have already shown that at high altitudes near the geomagnetic equator the trapped radiation is of different character and is in general more penetrating than that in high latitudes. This fact, combined with the intensity structure picture obtained from Figure 4 encourages the conjecture that the two zones may originate in different ways. The outer zone may have its origin in solar plasma, and the inner zone in cosmic-ray-albedo decay products, as suggested independently by S. N. Vernov, S. F. Singer, P. B. Kellogg, and by N. C. Christofilos.

Another possible explanation for existence of two high-intensity zones may be a selective radial diffusion of the trapped radiation within the earth's inhomogeneous magnetic field. This suggestion has been advanced by T. Gold. Such diffusion would depend upon the magnetic rigidities of the particles or upon a combination of their magnetic rigidities and the sign of their electrical charges.

It is important that the energy spectra of protons and electrons throughout the trapping region be learned. Of special interest are the spectral differences, if any exist, between the radiation in the inner and outer zones.

Radial Extent of the Effect of the Earth's Magnetic Field

Between 27,000 and 37,000 km from the earth's center, the counting rate declines steeply. Beyond 37,000 km, the counting rate continues to fall smoothly, but progressively less steeply with increasing radial distance. Beyond about 64,000 km, or 10 earth radii, the rate of decline is greatly decreased (Fig. 3).

Although no abrupt cut-off exists, it seems reasonable to consider 10 earth radii

as approximately the outer limit of the trapped radiation. At this distance, its intensity is substantially less than the intensity of interplanetary cosmic rays.

Interplanetary Cosmic Ray Intensity

The counting rate decreases very gradually beyond 10 earth radii. It seems to have reached an asymptotic value of 2.25 counts/sec at 17 earth radii, the farthest limit of the observations. The observed dependence of counting rate on radial distance makes it likely that the contribution of a residue of trapped radiation is negligible at a distance of 17 earth radii.

The denser portion of the earth's atmosphere subtends a solid angle of only 10^{-3} of a sphere at the probe's position when 17 earth radii out. Hence, the high-energy escape albedo of the earth is negligible at this distance, as is the atmosphere's capacity for scattering and absorption of high-energy, primary cosmic rays.

At this radius, the expected Stoermer cut-off—the minimum energy that particles must have to penetrate the geomagnetic field—is 0.03×10^9 volts magnetic rigidity; for protons, this corresponds to kinetic energies of 5×10^8 electron volts, for electrons, to kinetic energies of 3×10^7 electron volts.

From the observed counting rate at 17 earth radii, $J_0 = 3.6 \pm 0.8$ particles/cm²/sec, where J_0 is the interplanetary value of the omni-directional intensity of charged particles.

Counting Rate Beyond Ten Earth Radii

During about 12 hours of measurements beyond 10 earth radii, fluctuations in the counting rate of the standard counter remained within statistical expectations. Moreover, at lesser distances, the rate varied remarkably smoothly with time and space. This seems to indicate that the probe encountered no "blobs" of interplanetary plasma during this interval or that the radiation in any such blobs it may have met

was not sufficiently energetic to penetrate the Geiger-Mueller tube walls.

The solar-terrestrial situation prevailing during the Pioneer III flight has not yet

been critically assessed, but a preliminary report from the High Altitude Observatory, at Climax, Colorado, indicates mild to moderate solar activity.

Measurements of the Pacific Equatorial Countercurrent

The following material was supplied by John A. Knauss and Robert Pepin of the Scripps Institution of Oceanography, La Jolla, California.

New measurements made during the IGY more than triple the earlier estimates of total eastward transport of water in the Equatorial Pacific. The revision is based on measurements of (i) the Cromwell Current, which flows eastward beneath and counter to the South Equatorial Current (see *Bulletin No. 16*), and, more recently, of (ii) the Pacific Equatorial Countercurrent. The latter flows just south of the westward-flowing Pacific North Equatorial Current, but in an easterly direction.

Prior to the IGY, the Pacific Equatorial Countercurrent was pictured as relatively shallow, with velocity and flow falling off almost to zero at a depth of about 230 meters. This concept was arrived at through calculations based on temperature, salinity, and other measurements made by H. V. Sverdrup.

Direct current observations made on the Doldrums Expedition, third of three IGY oceanographic cruises by the Scripps Institution of Oceanography, modify this picture. It remains true that the highest velocities in the Pacific Equatorial Countercurrent occur in the top 150 m, and that the peak velocity is found at about 100 m, just above the thermocline region, where water temperature falls rapidly (see Fig. 5).

The expedition found, however, that the countercurrent does not vanish beneath the

thermocline, but continues to flow east at speeds of approximately 8-11 mi/day, and because it widens to 250-300 km, transports roughly 50% more water below the thermocline than above it.

Transport above the thermocline was in agreement with Sverdrup's estimate of

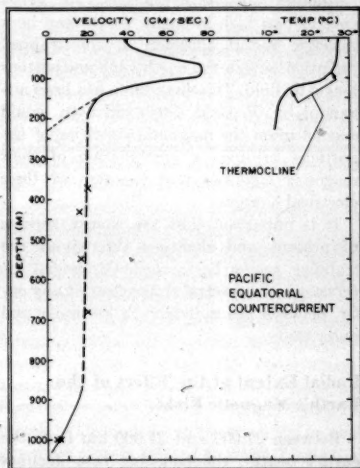


Fig. 5. Plot of Velocity and Temperature of the Pacific Equatorial Countercurrent. Velocity profile above 200 m is composite of 12 current-meter observations made in a two-week period; below 200 m, curve is drawn from six Swallow float measurements; depth of thermocline determined from bathythermograph observations. Short-dash line represents profile expected from earlier studies.

20-25 $\times 10^6 \text{ m}^3/\text{sec}$, being roughly calculated by the expedition at $20 \times 10^6 \text{ m}^3/\text{sec}$. Transport below was calculated at $30 \times 10^6 \text{ m}^3/\text{sec}$. Adding these to transport calculations for the Cromwell Current ($30 \times 10^6 \text{ m}^3/\text{sec}$) approximately triples previous estimates of the total volume of water transported eastward in the Equatorial Pacific.

The direct measurements of the Pacific Equatorial Countercurrent were made at about its center, at $7^\circ 52' \text{N}$, $107^\circ 30' \text{W}$. As

with the Cromwell Current, observations of the top 200 m were made by suspending a propeller-type current meter from a drifting ship. The apparent current velocity at different depths was obtained from the flow of water past the meter; at the same time, radar observations were made of the ship's drift from a fixed reference point, a taut-wire buoy anchored in 2200 fathoms. Below 200 m, measurements were made by electronic tracking of the drift of submerged, neutrally-buoyant Swallow floats.

Antarctic Notes

Ornithological Studies

Much information on the habits and movements of the South Polar skua, most southerly of all birds, was obtained during IGY. Carl Eklund reported at an IGY Symposium during the 125th meeting of the American Association for the Advancement of Science.

Approximately 1500 skuas were banded at Antarctic stations, and some returns have already been received from Australia indicating migrations to that continent, and from the Belgians, Russians, and Americans on unusual skua movements within Antarctica. Argentina, Japan, New Zealand, Norway, and the United Kingdom also participated.

Penguins and skuas were dyed or sprayed with one or a combination of colors to determine the effects of color on the social behavior of the birds and to study their daily and seasonal movements. Skua chicks were dyed in the eggs. The survival rate of colored versus unmarked chicks yielded some data on the protective effects of coloration.

Prior to the IGY, six Emperor Penguin rookeries had been discovered in the Antarctic and another was suspected. The total known population of these rookeries was less than 40,000 birds. Eight additional

rookeries were discovered during the IGY, and the total known Emperor Penguin population is now estimated at more than 135,000. The largest Emperor Penguin nesting area yet found is located at 73°S , 169°E , about 250 mi north of McMurdo Sound. This rookery, discovered from a helicopter in December 1958 by Captain John Cadwalader, United States Navy, and John Dearborn, biologist, contained an estimated 50,000 birds.

The Cape Crozier rookery, first visited in 1902 by Edward Wilson of the British National Antarctic Expedition, was revisited by New Zealand scientists in September 1957. It had shifted somewhat from its original position on the sea ice and its population had increased to about 1000 adult birds, roughly five times the number estimated during the earlier visit.

Lady Newnes Ice Shelf

The disappearance of over 1000 square miles of Lady Newnes Ice Shelf, south of the joint US-New Zealand Hallett Station, has been reported by US Navy personnel supporting IGY scientific activities in the area. An ice area ten times that of the District of Columbia and 300 ft thick has disintegrated since the last charting in 1912.

Ancient Rocks

What may be the first radioactive age determination of a rock from Antarctica is reported by S. S. Goldich, A. O. Nier, and A. L. Washburn (*Transactions, American Geophysical Union*, October 1958). Paragneiss bedrock from Gneiss Point, on the west side of McMurdo Sound, was dated at 520 million years by analysis of the ratio of the A^{40} to the K^{40} isotope in biotite separated from the gneiss. (Paragneiss is a gneiss—a coarse-grained, banded metamorphic rock—derived from sedimentary rock.) The sample was collected by R. P. Goldthwait and A. L. Washburn during a short geological reconnaissance trip in December 1957.

Gneiss Point is part of the East Antarctica Precambrian shield (see *Bulletin No. 19*). It is situated on the great fault zone believed to extend from McMurdo Sound to the Weddell Sea, separating Antarctica into two distinct regions structurally. Because of Gneiss Point's location on the fault zone and its close proximity to the volcanic islands of the Ross Sea, geologic interpretation of the 520-million-year age of the rocks at Gneiss Point must be cautious.

The ancient dating of these rocks supports the Precambrian age assigned to the East Antarctic shield. Moreover, if the Gneiss Point rocks have not been affected by geologic events subsequent to the formation of the paragneiss, the metamorphic rocks may indicate a period of orogeny, or mountain building, at the close of the Precambrian, about 510 million years ago, or in Cambrian time (430-510 million years ago). This theory is given some support by A^{40}/K^{40} dates of 490 million years for biotite from gneiss at Rio de Janeiro, Brazil, and of 530 million years for granite at Cape Town, South Africa.

Expedition to "Pole of Inaccessibility"

The USSR-IGY Participating Committee reports that an expedition from Mirny

Station reached the "pole of relative inaccessibility" in mid-December and established a temporary station for scientific observations. Located at $82^{\circ}06'S$, $59^{\circ}00'E$, this farthest-inland area of Antarctica is 3710 m above sea level.

Seismic soundings made every 30-100 km indicate considerable irregularity of the land surface beneath the ice between the USSR Sovietskaya IGY Station ($78^{\circ}24'S$, $87^{\circ}35'E$) and the pole of inaccessibility. The sub-ice surface appears to be above sea level virtually everywhere along the route.

At $81^{\circ}05'S$, $65^{\circ}E$, the land surface beneath the ice was tentatively reported to be 3000 m (almost 10,000 ft) above sea level. At the pole of inaccessibility itself the ice bottom was about 800 m above sea level, indicating a total ice thickness there of 2910 m, or about 9545 ft. Near Pioneer-skaya, one sounding showed the ice to extend to a depth of 1500 m below sea level. The snow surface at $80^{\circ}S$, $77^{\circ}E$ was found to be 4070 m, or 13,185 ft, above sea level.

Byrd Station Traverse

The 1958-59 oversnow traverse party from the US-IGY Byrd Station reported recently the discovery in the Horlick Mountains of sandstone-shale coal beds containing leaf fossils and petrified tree remains 12 ft long. The coal beds varied in thickness from a few inches to a few feet and continued in alternate layers with the sandstone and shale for nearly 2000 ft of section. Fossil bivalve shells were found in basal sands.

The Horlick Mountains extend eastward from the southeast end of the Ross Ice Shelf for hundreds of miles. The traverse party found the Horlicks to consist of sedimentary rocks overlying granites, resembling the mountains of Victoria Land. Members of the party climbed 4000 ft of sediments whose strike was generally east-west, parallel to the trend of the mountains; the rock layers dipped about 5° to the south.

Oxygen Isotope Studies

The following report is based upon material furnished by Samuel Epstein and Robert P. Sharp, Division of Geological Sciences, California Institute of Technology.

Laboratory determinations of the variations in the ratio of the O^{18} to the O^{16} isotope in glacial ice are of considerable value in ascertaining the relative temperature of the ice when it first fell as snow. Such analyses make it possible to distinguish the pattern of seasons where the annual ice layering has become obscured or where seasonal distinction is otherwise difficult.

In the Antarctic, oxygen-isotope ratios provide a means for identifying annual accumulation layers where other methods fail. Identification of these layers is essential for evaluating the accumulation rate of Antarctic ice bodies and their immediate past history. This, in turn, is related to fundamental problems such as world climatic changes and fluctuations of sea level. Study of the O^{18}/O^{16} ratio in ice cores from deep drill holes at Byrd and Little America IGY Stations should provide a record of relative climatic changes during the past 500 to 1000 years.

The analysis of O^{18}/O^{16} ratios in ice samples, collected at various locations in the Antarctic, Greenland, and from mountain glaciers in the continental United States and in Alaska, is being performed at the California Institute of Technology under the direction of Samuel Epstein.

Theoretical Considerations

From measurements of the isotopic composition of ocean waters, rain, snow, and ice it is possible to postulate a simple model to explain the gross variations in the H_2O^{18}/H_2O^{16} ratio in the meteorological cycle. Such variations result from the differences in vapor pressure between these isotopic molecules of water.

The behavior of this water is considered to be much like that of liquid and vapor

in a multi-stage distillation column with reflux. In such a column, the vapor rising from the boiler passes to cooler and cooler parts of the column, and as condensation occurs its content of the less volatile H_2O^{18} molecule is progressively depleted. As a result, the O^{18}/O^{16} ratio in the water becomes lower as the temperature of condensation decreases. Similarly, the O^{18}/O^{16} ratio of natural precipitation is closely related to temperature. The higher the latitude and the altitude, the less H_2O^{18} the precipitate should have. Furthermore, in any one locality, winter precipitation has a lower O^{18}/O^{16} ratio than summer precipitation.

The effect of temperature on the O^{18}/O^{16} ratio of rain and snow has been confirmed many times. Tropical rain contains the highest concentration of H_2O^{18} , snow the lowest. The precipitation in cooler, higher-altitude areas has less H_2O^{18} than that of lower-level areas. Because of this temperature effect, the O^{18}/O^{16} ratios in accumulated snows of permanent ice regions should reflect the altitude of accumulation and the seasonal variations in temperature. Thus, the variation of the O^{18}/O^{16} ratio in natural precipitation is useful in the study of many problems in glaciology.

Study of systematic seasonal variations aids in determination of rates of snow accumulation, in dating of snows, and in correlation of different stratigraphic layers. In addition, if variations in the O^{18}/O^{16} ratio of snows in the accumulation areas are known, it is possible to identify patterns of flow in the ice tongue and to measure subsequent alterations affecting the O^{18}/O^{16} ratio of ice.

Analysis Program

The task of analyzing snow and ice samples collected during IGY got underway slowly, partly because the samples began reaching the laboratory only recently and partly because it was desirable to have on hand as representative a selection of

samples as possible before attempting to analyze any particular set of them. Preliminary results are available from oxygen-isotope analysis of ice samples from Greenland, from the Blue Glacier, in Olympic National Park, Washington State, and from the IGY South Pole Station. Other Antarctic samples are under study.

In the included figures and table, δ represents the O^{18}/O^{16} ratio of the sample relative to the mean O^{18}/O^{16} ratio of ocean water, according to the following formula:

$$\delta = \left[\frac{O^{18}/O^{16} \text{ ratio of sample}}{\text{mean } O^{18}/O^{16} \text{ ratio of ocean water}} - 1 \right] 1000$$

Since $\delta = 0$ is the mean ratio for ocean water, negative values represent lower ratios and positive values higher ratios than that of ocean water.

Greenland: Through the cooperation of Carl Benson of the US Army Snow, Ice and Permafrost Research Establishment, a series of firn samples from depths of several meters were collected in pits at a number of localities on the Greenland icecap. (Firn is compact, granular snow that has lasted through at least one summer.) Samples of ice were also supplied from depths of about 100 and 300 m in one of the deep bore holes drilled by the SIPRE team.

Figure 6 shows the seasonal variation in O^{18}/O^{16} ratio of snow with depth for two collection sites in northern Greenland, 360 km apart and at elevations of about 2440 and 3060 m. The summer snows have the highest O^{18}/O^{16} values relative to the mean values in ocean water, and the winter snows have the lowest (i.e., more negative) values. (In some cases, the variations are as much as 200 times the precision of measurement.)

The differences in amplitude of the O^{18}/O^{16} ratio variations shown in Figure 6 are worth noting. In spite of the great distance separating the two sites, there is surprisingly good correlation of these amplitudes for the same year of accumulation. For these sites, the summer and winter accumulation layers were identified independently

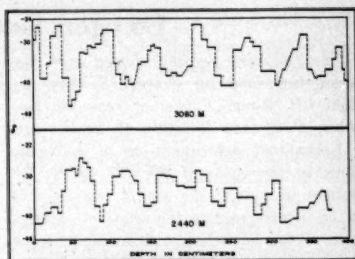


Fig. 6. Seasonal Variation of the O^{18}/O^{16} ratio, δ , with Depth at Two Sites in Greenland. The sites, at heights of 10,000 and 8,000 ft (3060 and 2440 m) are 360 km apart.

by glaciological evidence prior to the isotope study. The results of the two methods compare almost perfectly.

Figure 7 shows the seasonal variations at depths of about 100 and 300 m in the SIPRE deep bore hole in Greenland. Even at these depths, where most of the grain characteristics of the ice have been obliterated, the seasonal variations in the O^{18}/O^{16} ratio are still preserved. Thus, where other criteria failed, it was possible to use isotope data to determine rates of accumulation for ice at least 800 years old.

TABLE 1
Snow and Firn Samples from South Pole
IGY Station

	Depth (cm)	δ
SP-101 Shallow Pit #2	40-45	-52.35
SP-102 " " "	80-85	-52.82
SP-103 " " "	115-120	-52.37
SP-30 Main Pit	195-200	-49.89
SP-29 " "	245-250	-46.50
SP-28 " "	280-285	-47.29
SP-27 " "	275-280	-46.87
SP-26 " "	320-325	-44.42
SP-25 " "	345-350	-47.51
SP-24 " "	382-387	-50.86
SP-23 " "	420-425	-47.64
SP-22 " "	465-470	-48.43
SP-21 " "	510-515	-49.89
SP-5 " "	855-860	-50.82
SP-15 " "	1265-1270	-47.70
SP-9 Deep Pit #1	1071-1076	-47.70

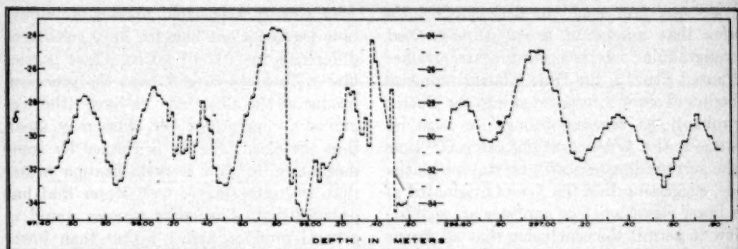


Fig. 7. Seasonal Variations in O^{18}/O^{16} Ratios at Depths of about 100 and 300 m in the SIPRE deep-bore hole in Greenland.

IGY South Pole Station: The Greenland analyses, now nearly completed, demonstrate the validity of certain basic relations in the isotope ratio of ice and snow that can be applied to samples from the Antarctic. Table 1 shows some of the data for the South Pole station. Unfortunately, not enough samples were collected from a single accumulation layer to determine the regularity of the seasonal variation. On the other hand, large variations in the O^{18}/O^{16} values relative to the mean sea-water value exist, and the regularity and amplitude of this variation can be tested by further samplings. The O^{18}/O^{16} ratios in the South Pole samples are the lowest yet measured, confirming the basic premise regarding temperature control.

Blue Glacier: On Blue Glacier (see *Bulletin No. 11*), samples of snow, firn, and ice were collected for O^{18}/O^{16} ratio analysis at sites ranging from the glacier's terminus to well up in the firn basins. E. R. LaChapelle and colleagues, of the University of Washington, collected specimens of snow as it fell during the winter on the upper part of the glacier. Epstein, Sharp, and their associates, from Caltech, made similar collections on the remainder of the ice stream. These same layers were sampled again months later. When analyzed, the later samples will indicate the changes in O^{18}/O^{16} ratio, if any, that occurred during the processes of firnification in the intervening interval.

Samples were taken along two longitudinal profiles, one on each of the two principal ice streams, from the firn limit almost to the terminus. Several transverse profiles across the glacier below the firn limit were sampled in detail. Additional sites were sampled locally to test special relations, including a core hole for determining possible changes of O^{18}/O^{16} ratios with depth. In addition, samples of firn taken from three separate pits at different elevations will afford a means of checking and evaluating the effect of altitude of accumulation on O^{18}/O^{16} ratios.

Only a few of the Blue Glacier samples have been analyzed as yet, but the data thus far available permit the following tentative conclusions:

- 1) The snow and firn feeding the Blue Glacier are relatively rich in O^{18} , as would be expected from the modest winter temperatures, the maritime nature of the environment, and the relatively short period of precipitation of the air masses involved prior to their arrival over the Olympic peninsula.

- 2) It appears that winter snow may be enriched in O^{18} during the process of firnification, as might be expected if the refreezing of melt water is the principal process involved. However, the data are as yet too few to be reliable, and they are not completely consistent.

3) Analyses made to date support the idea that masses of *firneis* (fine-grained, equigranular ice resembling coarse-grained thawed firn) in the Blue Glacier represent bodies of snow incorporated into the glacier, probably as crevasse fillings. In most instances, the *firneis* contains more O^{18} than the surrounding, coarsely crystalline glacier ice, suggesting that the *firneis* originated at a lower elevation. The analyses are still too few to permit the conclusion that all *firneis* is of this origin.

4) Closely associated masses of bubbly blue ice and clear blue ice have consistent differences in O^{18}/O^{16} ratios. These particular differences suggest that the processes producing the clear blue ice have either removed O^{18} or added O^{18} . This may mean that the clear blue ice is formed by some mechanism of slow recrystallization rather than by refreezing of melt water that has permeated it. The latter process would in general produce higher rather than lower O^{18}/O^{16} .

Structure and Circulation of the Stratosphere

The following report is based upon a paper given at the IGY Symposium at the Meeting of the American Association for the Advancement of Science, Washington, D. C., December 29-30, 1958, by Sidney Teweles, US Weather Bureau.

With the aid of the large quantity of high-altitude data obtained during the IGY, meteorologists are now beginning a greatly intensified program of research into the exact nature of the stratosphere. (The stratosphere is here taken to be the atmospheric layer extending downward from the 35-km level to the tropopause, which forms the upper limit of the troposphere, approximately 10 km high at the poles and 18 km high at the equator.)

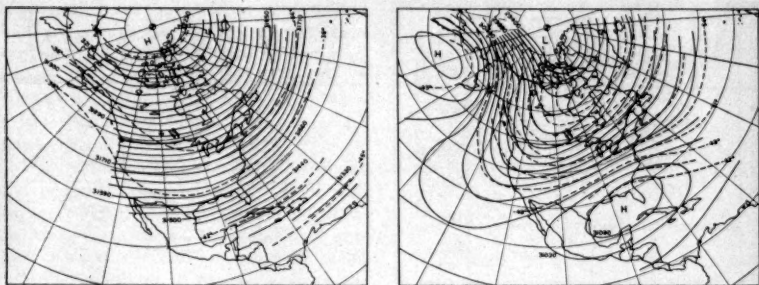
Analysis of IGY data will permit a much more accurate description of the temperatures, flow, and density of the stratosphere. This information is required, not only as a basis for further theoretical investigations, but also for application to immediate problems arising from current and anticipated traffic of aircraft, rockets, missiles, and balloons in and through the stratosphere. Furthermore, although only about 2% of the mass of the atmosphere exists above 25 km, some meteorologists believe that processes taking place above this level, where the

sun's energy is first absorbed, may be significantly linked with the major motions in the troposphere.

Outline of Program

The collection of stratospheric data during the IGY was noteworthy in several respects: the number of radiosonde stations in polar and equatorial areas was greatly increased; station networks were filled out; the number of night balloon flights into the stratosphere was greatly increased by special conditioning of balloons to withstand very low temperatures; larger balloons (800-gm capacity) carried the instruments to greater heights than ever before. By these means, sufficient synoptic data on the upper portion of the stratosphere were gained to permit analysis of horizontal temperature and flow patterns up to the 31-km level.

A large percentage of the data was evaluated and transmitted almost instantly throughout the world, so that large-scale phenomena could be studied even as they occurred. Nevertheless, the fullest results of the IGY will follow careful future studies, based upon the complete, checked data that will soon emanate from the IGY World Data Centers.



Figs. 8 (left) and 9. 10-mb Pressure Surface Over North America on July 15 and November 15, 1957, Respectively. Heights in meters (solid line); temperatures in degrees Centigrade (dashed line); contour interval, 30 m (left) and 120 m (right).

A gross division of the stratosphere into upper and lower layers and into equatorial, mid-latitude, and polar zones can already be made. To analyze the interactions between these layers and zones, and the variations between hemispheres and between seasons, is a complex task requiring the integrated efforts of many specialists throughout the world.

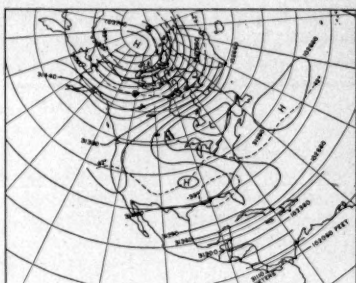
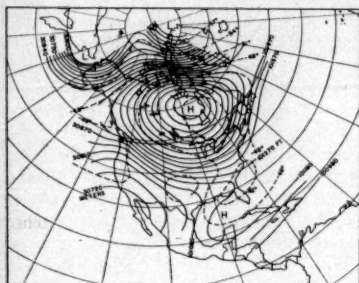
The preliminary digestion of raw IGY data in analysis centers has already been arranged and will permit many research groups to begin their studies at a more advanced stage. As a contribution to the stratospheric research effort, the US Weather Bureau has begun the production of 100-mb (16-km) and 50-mb (20-km) constant-pressure-surface charts of the Northern Hemisphere and has under consideration the analysis of 30-mb (24-km) and 10-mb (31-km) charts, pole-to-pole cross sections, and stratospheric constant-pressure charts for one or more surfaces in the Southern Hemisphere. A group of 10-mb charts prepared from IGY data are discussed below, along with some preliminary results of other IGY stratospheric studies.

Analysis of 10-mb Charts

The 10-mb charts for North America are the first to show temperature, pressure, and wind conditions near the 31-km level over

such a large area. On July 15, 1957 (Fig. 8), the stratosphere at the 10-mb level above the North Pole was about 12° C warmer than over the equator, and the winds were from the east everywhere over North America. The stratosphere in the North Polar region then cooled rapidly and winds switched to a westerly direction. By November 15 (Fig. 9), the polar region had cooled by as much as 40° C and winds had accelerated to more than 100 knots in portions of the westerlies that encircled the polar regions. East winds continued to blow in the tropics.

The warm high-pressure cell over the Aleutians is apparently a frequent feature of the stratospheric circulation. This cell retreats and advances, expands and contracts. In some years, as shown by the chart for February 15, 1958 (Fig. 10), it intensifies and moves across the pole or into another portion of the stratosphere, which, like that over eastern Canada, is usually characterized by cold air and low pressure. The warming of the cold region may be very sudden and is usually accompanied by a dramatic change of stratospheric circulation. When the warming occurs early in the winter, there is time for the polar region to cool again and the westerlies to become re-established, as they did in 1958. By May 15, however, the heating of the polar regions by the returning sun produced an ex-



Figs. 10 (left) and 11. 10-mb Pressure Surface on February 15 and May 15, 1958, Respectively. Heights in meters and feet; temperatures in degrees Centigrade; contour interval 30 m.

panding belt of east winds around the Arctic Circle (Fig. 11), and by mid-June, the east winds again dominated the stratosphere of the Northern Hemisphere.

Sudden Warming of the Stratosphere

Since the winter of 1952, when a sudden warming of the stratosphere was discovered over Berlin, there has been great curiosity about this phenomenon. Some of the early explanations, based on the assumption that the warming was a localized phenomenon, have been abandoned. It is now believed that sudden warming in the polar stratosphere is a manifestation of the fundamental energy transformations associated with major changes in the hemispheric circulation of the high levels.

A rough comparison of the year-to-year variations in the warming phenomenon since 1951 has been made by examining 10-day mean temperatures of the 50-mb surface over Alert, N.W.T., Canada, at $82^{\circ}30'N$. The most radical temperature changes were those beginning in January of the years 1952, 1957, and 1958. The 1957 warming, in fact, covered the entire extreme range of temperatures measured up to that time at Alert. Temperature increases occurring earlier in the cold season were smaller in range, of short duration, and were followed

by another period of cooling. Temperature increases occurring near the time of the spring equinox led directly into summertime warmth.

IGY data from Drifting Station Alpha in the Arctic Ocean and from the IGY South Pole station, provide comparison between stratosphere warmings in the two polar regions. In 1957, the temperature of the Arctic stratosphere reached a peak late in the mid-winter month of January. In both 1957 and 1958 at the South Pole, the major warming was delayed until October, after the return of sunlight to the polar stratosphere. At the peak of the Antarctic springtime warming, the temperature exceeded any measured during the summer that followed. Just prior to the time of the peak temperature at either pole, very strong stratospheric winds are observed, indicating passage of the axis of the stratospheric jet stream across the pole as an accompanying phenomenon.

Perturbations in the Circulation of the Upper Stratosphere

Although the day-to-day changes in tropospheric winds, due to rapidly moving small-scale weather systems, are mirrored in the lower stratosphere, their influence decreases with altitude. In the upper stratosphere above the 50-mb level, very slowly

moving, large-scale patterns that extend halfway around the hemisphere dominate the circulation. Rapidly moving perturbations in the wind field, similar to those with which we are familiar at sea level, if they exist at all in the upper stratosphere, are apparently of small amplitude.

Wind direction graphs used to determine the periodicity of high stratospheric disturbances show little evidence of the four- to seven-day period characteristic of surface systems. Instead, a period of about fifteen days seems to dominate. Since the large-scale patterns of the troposphere, utilized in making long-range forecasts of the trajectories of storms and air-masses, are also slow-moving, the large-scale patterns of these two atmospheric layers may be interrelated. Thus, circulation changes in the stratosphere are expected to provide important clues in long-range forecasting of surface conditions. It is also anticipated that the reverse will apply, that tropospheric events may be used in making forecasts for the stratosphere—for example, in forecasting the initiation of the intense stratospheric cyclones and anticyclones that accompany sudden warming at high levels. A greatly expanded program is now being planned in this field.

Another phase of the IGY observational program—ozone measurement—gives added evidence of periodicity in the stratosphere. The total ozone in the atmosphere above Moosonee, Ontario, during November, 1958, has been compared with available 100-mb and 50-mb temperatures at that station (see Fig 12). The 100-mb temperature and total ozone rise and fall together, with a periodicity of six to nine days, corresponding to that of surface systems at this latitude. However, these changes are superimposed on a long-period trend that becomes more dominant at the 50-mb surface and above.

The close correlation between total ozone and temperatures at the 100-mb level is truly remarkable since total ozone is meas-

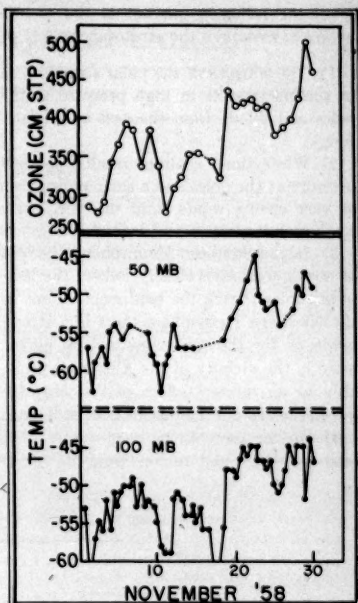


Fig. 12. Comparison of Total Ozone (at Standard Temperature and Pressure) With Temperatures at the 50- and 100-mb Levels Over Moosonee, Ontario, During November 1958.

ured entirely by a surface instrument, the Dobson spectrophotometer. During the IGY, many of these instruments were installed in remote areas. The correlation of ozone variations with those of a host of other types of meteorological measurements may help to answer one of the major mysteries of the upper air—how and where does air pass back and forth between the troposphere and the stratosphere?

Concluding Remarks

The ability of meteorologists during the IGY to obtain, at ever higher atmospheric levels, sufficient synoptic data for a full analysis of the temperature and wind fields

gives the following picture of the annual course of events in the stratosphere:

1) The warmth of the polar stratosphere in summer results in high pressure at the poles and winds from the east at all latitudes.

2) Wintertime cooling results in low pressure at the poles and a surrounding belt of very strong winds from the west, with weaker westerlies in mid-latitudes.

3) In the Southern Hemisphere, the belt of strong westerlies closely follows the latitude circles during the cold months, but in the Northern Hemisphere there is a strong tendency for the westerlies to loop northward in the vicinity of the Aleutians, probably as an indirect effect of the powerful jet stream in the troposphere over Japan.

4) One or more times each winter, this loop amplifies and moves from its usual

position, causing warm air to flood across the pole and the cold polar air to be displaced into mid-latitudes.

5) At the South Pole, stratospheric heating has been observed to occur only after the sun returns in the spring and is climaxed by a final surge of extreme heating as the circulation around the pole reverses from westerly to easterly.

6) The large scale of stratospheric motions suggests that relationships important to long-range forecasting will eventually be shown to exist between them and the large-scale motions of the troposphere.

7) The study of daily values of some unusual meteorological elements, measured in some selected parts of the globe for the first time, may close some of the gaps in our understanding of the complex general circulation of the atmosphere and lead to novel forecasting methods.

IGY Bibliographic Notes

This is the eighth of a series of bibliographic notes on IGY programs and findings. The references are selected from an IGY bibliography under preparation in the Science and Technology Division of the Library of Congress. (An interim bibliography prepared by the Library and published by the National Academy of Sciences, with support by the National Science Foundation, is available from the Academy for \$1.00.)

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